Review

Essential Oils of Lamiaceae Family Plants as Antifungals

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Abstract: The incidence of fungal infections has been steadily increasing in recent years. Systemic mycoses are characterized by the highest mortality. At the same time, the frequency of infections caused by drug-resistant strains and new pathogens e.g., Candida auris increases. An alternative to medicines may be essential oils, which can have a broad antimicrobial spectrum. Rich in the essential oils are plants from the Lamiaceae family. In this review are presented antifungal activities of essential oils from 72 Lamiaceae plants. More than half of these have good activity (minimum inhibitory concentrations (MICs) < 1000µg/mL) against fungi. The best activity (MICs < 100) have essential oils from some species of the genera Clinopodium, Lavandula, Mentha, Thymbra, and Thymus. In some cases were observed significant discrepancies between different studies. In the review are also shown the most important compounds of described essential oils. To the chemical components most commonly found as the main ingredients include β-caryophyllene (41 plants), linalool (27 plants), limonene (26), β-pinene (25), 1,8-cineole (22), carvacrol (21), α-pinene (21), p-cymene (20), γ-terpinene (20), and thymol (20).

Keywords: Labiatae; fungi; Aspergillus; Cryptococcus; Penicillium; dermatophytes; β-caryophyllene; sesquiterpene; monoterpenes; minimal inhibitory concentration (MIC)

1. Introduction

Fungal infections belong to the most often diseases of humans. It is estimated that about 1.7 billion people (25% of the population) have skin, nail, and hair fungal infections [1]. The development of most of these infections is affected by dermatophytes, namely Trichophyton spp., Microsporum spp., and Epidermophyton spp. [2]. Simultaneously, mucosal infections of the oral and genital tracts caused by Candida spp. are very common. About 0.13 billion of women suffer from vulvovaginal candidiasis. On the other hand, oral candidiasis are common in babies and denture wearers. Fungi also cause life-threatening systemic infections, with mortality reaching >1.6 million, which is >3-fold more than malaria [3]. Among life-threatening fungal infections prevail cryptococcosis (Cryptococcus neoformans) with >1,000,000 cases and mortality rate 20–70%, candidiasis (Candida albicans) with >400,000 cases and mortality rate 46–75%, pneumocystosis (Pneumocystis jirovecii) with >400,000 cases and mortality rate 20–80%, and aspergillosis (Aspergillus fumigatus) with >200,000 cases and mortality rate 30–95% [1,4,5]. In Table 1 are presented diseases caused by some of the most often fungal pathogens among people.
| Table 1. Fungal pathogens of humans and most often observed mycoses (based on [6,7]). |
|---------------------------------|---------------------------------|
| **Superficial mycoses**         | • Hortae werneckii (Tinea nigra) |
|                                 | • Malassezia furfur (Pityriasis versicolor) |
|                                 | • Piedraia hortae (Black piedra) |
|                                 | • Trichosporon spp. (White piedra) |
| **Cutaneous and subcutaneous mycoses** | • Aspergillus spp. (Onychomycosis, Keratitis) |
|                                 | • Candida spp. (Tinea pedis, Tinea cruris, Onychomycosis, Keratitis) |
|                                 | • Chaetomium spp. (Subcutaneous phaeohyphomycosis) |
|                                 | • Curvularia spp. (Subcutaneous phaeohyphomycosis) |
|                                 | • Epidermophyton spp. (Tinea pedis, Tinea cruris, Onychomycosis) |
|                                 | • Exophiala spp. (Chromoblastomycosis, Subcutaneous phaeohyphomycosis) |
|                                 | • Fonsecaea spp. (Chromoblastomycosis) |
|                                 | • Fusarium spp. (Onychomycosis, Keratitis, Eumycotic mycetoma) |
|                                 | • Geotrichum spp. (Onychomycosis) |
|                                 | • Microsporum spp. (Tinea corporis, Tinea capitis) |
|                                 | • Phaeoacremonium spp. (Eumycotic mycetoma) |
|                                 | • Phialophora spp. (Chromoblastomycosis, Subcutaneous phaeohyphomycosis) |
|                                 | • Scopulariopsis brevicollis (Onychomycosis) |
|                                 | • Sporothrix schenckii (Lymphocutaneous sporotrichosis) |
|                                 | • Trichophyton spp. (Tinea pedis, Tinea corporis, Tinea cruris, Tinea capitis, Onychomycosis) |
|                                 | • Trichosporon spp. (Onychomycosis) |
| **Endemic mycoses**             | • Blastomyces dermatitidis ( Blastomycosis) |
|                                 | • Histoplasma capsulatum (Histoplasmosis) |
|                                 | • Coccidioides immitis/posadasii (Coccidioidomycosis) |
|                                 | • Penicillium marneffei (Penicilliosis) |
|                                 | • Paracoccidioides brasiliensis (Paracoccidioidomycosis) |
| **Opportunistic mycoses**       | • Acremonium spp. (Hyphalohyphomycosis-cutaneous, disseminated infection) |
|                                 | • Alternaria spp. (Phaeohyphomycosis-subcutaneous, sinusitis, disseminated infection) |
|                                 | • Aspergillus spp. (Allergic reactions, Aspergillosis-nasal, sinusitis, bronchial, pulmonary, systemic dissemination) |
|                                 | • Bipolaris spp. (Phaeohyphomycosis-subcutaneous, sinusitis, brain abscess) |
|                                 | • Candida spp. (Candidiasis-superficial mucosal, cutaneous, widespread hematogenous distribution involving target organs) |
|                                 | • Cryptococcus spp. (Cryptococcus-cutaneous, pulmonary, meningitis) |
|                                 | • Curvularia spp. (Phaeohyphomycosis-subcutaneous, sinusitis, disseminated infection) |
|                                 | • Fusarium spp. (Hyphalohyphomycosis-cutaneous, disseminated infection) |
|                                 | • Geotrichum spp. (Eumycotic mycetoma) |
|                                 | • Lichtheimia spp. (Mucormycosis-cutaneous, invasive) |
|                                 | • Mucor spp. (Mucormycosis-cutaneous, invasive) |
|                                 | • Paecilomyces spp. (Hyphalohyphomycosis-cutaneous, disseminated infection) |
|                                 | • Pneumocystis jirovecii (Pneumocystosis-pneumonia, extrapulmonary manifestations) |
|                                 | • Rhizomucor spp. (Mucormycosis-cutaneous, invasive) |
|                                 | • Rhizopus spp. (Mucormycosis-cutaneous, invasive) |
|                                 | • Scedosporium spp. (Hyphalohyphomycosis-cutaneous, disseminated infection) |
|                                 | • Trichosporon spp. (Trichosporonosis-invasive disease) |
|                                 | • Wangiella spp. (Phaeohyphomycosis-subcutaneous, sinusitis, brain abscess) |
The big problem is growing drug-resistance amid fungi. Among Candida and Aspergillus species is observed resistance to azoles, e.g., to fluconazole, voriconazole, and posaconazole. Some Candida species, especially C. glabrata and C. parapsilosis, can be echinocandin- and multidrug-resistant [8,9]. Acquired resistance to echinocandins has also been reported for yeasts C. albicans, C. tropicalis, C. krusei, C. kefyr, C. lusitaniae, and C. dubliniensis [10]. More than 3% of Aspergillus fumigatus isolates are resistant to one or more azoles [11]. Polyene resistance mainly concerns amphotericin B. Resistance to this drug is observed in Fusarium spp., Trichosporon spp., Aspergillus spp., and Sporothrix schenckii [12,13]. Resistance to amphotericin B has also been reported for C. albicans, C. glabrata, and C. tropicalis [14–16]. Cultures of some Candida species and Cryptococcus neoformans are presented in Figure 1.

The new epidemiological problem is C. auris, a multidrug-resistant organism first described in Japan in 2009 [17]. Recently, C. auris has been reported from 36 countries from six continents [18]. About 30% of isolates demonstrate reduced susceptibility to amphotericin B, and 5% can be resistant to the echinocandins [19,20]. The estimated mortality from C. auris fungemia range from 28% to 60% [21].

Fundamental issues are also the costs of treatment and hospitalization of patients with invasive fungal diseases. According to Drgona et al., all costs range from around €26,000 up to over €80,000 per patient [5].

Therefore, all time, new treatments for fungal infections are being sought. One option may be to apply natural products having antifungal activity. Among these, significant importances have essential oils, which can have a broad antimicrobial spectrum. Rich in the essential oils are among other plants from the Lamiaceae family.

In this review are presented antifungal activities of essential oils from seventy-two (72) plants of the Lamiaceae family. Moreover, are shown the most important compounds of these essential oils. For objective comparison of results, in this paper were included only antifungal studies specifying the minimum inhibitory concentrations (MICs) for essential oils. The MIC (expressed in µg/mL) is the

Figure 1. Cultures of selected yeast fungi on Sabouraud agar (Author of photos: Tomasz M. Karpiński).
lowest concentration of an antimicrobial agent in which no growth of a microorganism is observed in an agar or broth dilution susceptibility test [22–24].

2. Components of Essential Oils of Lamiaceae Family

The family Lamiaceae or Labiatae contains many valuable medicinal plants. In the family are 236 genera and between 6900 and 7200 species. To the most abundant genera belong *Salvia* (900 species), *Scutellaria* (360), *Stachys* (300), *Plectranthus* (300), *Hyptis* (280), *Teucrium* (250), *Vitex* (250), *Thymus* (220), and *Nepeta* (200). Lamiaceae plants rich in essential oils have great worth in natural medicine, pharmacology, cosmetology, and aromatherapy [25]. The essential oils are mostly present in leaves, however, they can be found in flowers, buds, fruits, seeds, rind, wood, or roots [26]. Essential oils are mixtures of volatile compounds, which are secondary plant metabolites. They play a role in the defense system of higher plants [27]. Essential oils may contain over 300 different compounds, mainly of molecular weight below 300 [28]. Some oils, e.g., obtained from *Lavandula*, *Geranium*, or *Rosmarinus*, contain 450 to 500 chemicals [29]. Among the active compounds of essential oils are various chemical classes, e.g., alcohols, ethers, aldehydes, ketones, esters, phenols, terpenes (monoterpenes, sesquiterpenes), and coumarins [30,31].

In Table 2 are presented the main chemical components of essential oils of selected Lamiaceae family plants. Plant names were unified according to The Plant List [32], however synonyms used in the literature were also left. Chemical component names were unified, according to PubChem [33].

| Essential Oil | Main Chemical Components | References |
|---------------|--------------------------|------------|
| *Aeollanthus suaveolens* Mart. ex Spreng. = *A. heliotropioides* Oliv. | Linalool (38.5%), α-Farnesene (25.1%), Massoialactone (4.5%), β-Caryophyllene (3.6%), Germacrene D (2.0%) | [34] |
| *Agastache rugosa* (Fisch. and C.A.Mey.) Kuntze | Methyl chavicol (93.45%), Methyl eugenol (2.48–50.51%), Estragole (8.55%), Eugenol (0.15–7.54%), Thymol (3.62%), Pulegone (2.56%), Limonene (2.49%), β-Caryophyllene (1.19–2.38%), | [35,36] |
| *Ballota nigra* subsp. *foetida* (Vis.) Hayek | β-Caryophyllene (21.8–22.6%), Caryophyllene oxide (18.0–20.5%), Germacrene D (13.1–16.5%), 2-Hexenal (6.5–11.2%), 1-Octen-3-ol (3.5–5.5%), β-Pinene (1.6–4.4%), Limonene (2.2–4.1%), Linalool (1.2–3.5%), β-Bourbonene (1.5–2.7%), α-Humulene (2.2–2.6%), α-Copaene (1.3–2.2%) | [37] |
| *Clinopodium dalmaticum* (Benth.) Bräuchler and Heubl = *Microseris dalmatica* Benth. | Piperiterrone oxide (41.77%), Pulegone (15.94%), Piperitene (10.19%), Limonene (5.77%), Piperitone (3.39%), α-Pinene (2.9%), β-Pinene (2.16%) | [38] |
| *Clinopodium nepeta* subsp. *glandulosum* (Req.) Govaerts = *Calamintha glandulosa* (Req.) Bentham = *Calamintha officinalis* Moench | Piperiterrone (trace–42.6%), Piperitene (0.0–40.3%), Carvone (1–38.7%), Pulegone (0.6–9.7%), Shisofuran (0.1–9.7%), Menthone (trace–8.3%), Dihydrocarvool acetate (0.1–7.6%), Dihydrocarvool (0–6.9%), 1,8-Cineole (0.0–6.4%), cis-Carvyl acetate (0.0–6.1%), | [39,40] |
| *Clinopodium nepeta* (L.) Kuntze = *Calamintha nepeta* (L.) Savi | Pulegone (2.4–84.7%), Isomenthene (1.9–51.3%), Menthone (0.0–35.4%), Carysanthone (1.3–33.9%), 1,8-Cineole (0.3–21.4%), Piperiterrone oxide (0.0–19.1%), Limonene (0.0–13.6%), Isopulegone (0.0–9.4%), Piperitene (0.0–7.7%), Cinerolone (0.0–5.8%), Isopulegol (0.0–4.1%), Isomenthol (0.0–3.9%), β-Caryophyllene (0.0–3.8%), 3-Octanol (0.0–3.0%), β-Pinene (0.0–2.3%), cis-Piperitene oxide (0.0–2.2%) | [41,42] |
| Essential Oil | Main Chemical Components | References |
|---------------|--------------------------|------------|
| *Clinopodium thymifolium* (Scop.) Kuntze = *Micromeria thymifolia* (Scop.) Frisch | Pulegone (32.81%), Piperitenone (25.7%), Piperitone (11.71%), Isomenthone (4.98%), Limonene (2.4%), β-Caryophyllene (2.39%) | [38] |
| *Clinopodium umbrosum* (M.Bieb.) Kuntze = *Calamintha umbrosa* Benth. | β-Caryophyllene (13.9%), Germacrene D (11.6%), Spathulenol (10.6%) | [43] |
| *Dracocephalum heterophyllum* Benth. | Citronellol (74.2%), Geraniol (2.8%), cis-Rose oxide (2.2%), Citronellyl acetate (1.7%) | [44] |
| *Hymenocrater longiflorus* Benth. | δ-Cadinol (18.49%), α-Pinene (10.16%), p-Menth-1-en-8-ol (9.82%), Hedycaryol (6.42%), β-Eudesmol (4.56%), Spathulenol (4.14%), δ-Cadinenol (3.02%), Linalool (2.98%), β-Caryophyllene oxide (2.81%), β-Bourbonene (2.72%), β-Caryophyllene (2.29%) | [45] |
| *Hyptis ovalifolia* Benth. | (R)-6-[2(Z)-1-Heptenyl]-5,6-dihydro-2H-pyran-2-one (60.0%), γ-Cadinene (6.6%), Viridiflorol (6.08%), Caryophyllene oxide (4.98%), γ-Elemene (4.38%) | [46] |
| *Hyssopus officinalis* L. | Pinocamphone (5.78–50.77%), 1,8-Cineole (0.47–36.43%), Pinocarvone (0.44–23.4%), β-Pinene (13.38–19.55%), Isopinocamphone (15.32%), α-Phellandrene (trace–3.74%), Sabine (1.7–2.9%), Myrtenol (1.39–2.27%), α-Pinene (1.01–2.57%), cis-Sabinene hydrate (0.0–2.5%), Myrtenyl methyl ether (1.64–2.21%) | [44,47,48] |
| *Lavandula angustifolia* Mill. | Linalool (20.18–45.8%), Linalyl acetate (4.6–43.13%), Lavandulyl acetate (0–16.01%), 1,8-Cineole (0.6–13.1%), Camphor (0.52–11.2%), Borneol (0.76–7.5%), Terpinen-4-ol (1.05–5.8%), β-Caryophyllene (0.6–4.95%), Lavandulol (0–16.01%), α-β-Ocimene (1.5–2.84%), Myrcene (0.4–2.41%) | [49–51] |
| *Lavandula multifida* L. | Carvacrol (41.5–42.8%), β-Ocimene (27.0–27.4%), Myrcene (5.3–5.7%), α-β-Isobolene (5.0–5.6%), Terpinolene (2.1–3.1%), α-Farnesene (2.6–2.8%) | [52] |
| *Lavandula pedunculata* (Mill.) Cav. | Fenchone (6.2–44.5%), 1,8-Cineole (5.1–34.3%), Camphor (8.7–34.0%), β-Pinene (14.9–0.0%), α-Pinene (2.5–8.0%), Camphene (0.8–6.1%), Linalool (0.5–3.8%), Bornyl acetate (0.9–3.5%), Borneol (0.6–3.4%), α-Cadinol (0.2–3.1%), cis-Verbenol (0.2–2.8%), Myrtenal (0.8–2.4%), trans-Verbenol (1.1–2.0%) | [53] |
| *Lavandula stoechas* L. | Fenchone (0.0–36.2%), 1,8-Cineole (0–33.9%), Camphor (2.2–18%), α-trans-Necrodyl acetate (0.0–17.4%), Lavandulyl acetate (0.0–7.6%), α-trans-Necrodol (0.0–7.1%), Linalool (0.0–6.2%), α-Copaene-8-ol (0.7–4.7%), Viridiflorol (1.4–3.6%), α-Pinene (1.1–3.2%), 2,3,4,4-Tetramethyl-5-methylene-cyclopenten-1-one (0.0–2.8%), Lyratyl acetate (0–2.4%), Myrtenyl acetate (1.0–2.0%), 1,1,2,3-Tetramethyl-4-hidroximethyl-2-cyclopentene (0.0–2.0%) | [51,54] |
| *Lavandula viridis* L’Her. | 1,8-Cineole (34.5–42.2%), Camphor (13.4%), α-Pinene (9.0%), Linalool (6.7–7.9%) | [55] |
| *Lepechinia mutica* (Benth.) Epling | Δ3-Carene (8.69–24.23%), Thujaops-2-α-ol (0.0–11.9%), Shyobunol (0.0–10.8%), β-Pinene (3.78–7.96%), δ-Cadinene (0.0–6.96%), Globulol (0.0–5.91%), Valerianol (0.0–5.19%), α-Pinene (0.0–4.62%), β-Caryophyllene (0.0–4.55%), Limonene (3.79–4.47%), α-Eudesmol (0.0–4.47%), α-Phellandrene (0.34–3.8%), β-Phellandrene (3.79%), γ-Cadinene (0.0–2.86%), α-Pine (1.23–2.68%), α-Cymene (0.0–2.04%), Isobornyl acetate (0.0–2.2%) | [56,57] |
Table 2. Cont.

| Essential Oil | Main Chemical Components | References |
|---------------|--------------------------|------------|
| Marrubium vulgare L. | γ-Eudesmol (11.93%), β-Citronellol (9.9%), Citronellyl formate (9.5%), Germacrene-D (9.37%), Geranyl formate (6.25%), Geranyl tiglate (5.53%), Ledene (5.35%), 1,8-Cineole (3.72%), Neryl acetate (3.41%), δ-Cadinene (3.3%), Cyclononasiloxane octadecamethyl (3.08%), Geraniol (2.74%), N-trimethylsilyl trifluoroacetamide (2.35%), Eicosamethylcyclocasiloxane (2.29%), α-Thujone (2.29%), trans-Caryophyllene (2.15%) | [58] |
| Melissa officinalis L. | Geranial (23.4%), Neral (16.3%), Citronellal (13.7%), β-Caryophyllene (4.6%), Geraniol (3.4%), Isomenthone (3.0%), Menthol (2.9%), Methyl citronellate (2.7%), Germacrene D (2.4%), Limonene (2.2%) | [59] |
| Mentha cervina L. | Isomenthone (8.7–77%), Pulegone (12.9–75.1%), Menthol (0.8–4.4%), Limonene (0.8–4.3%) | [60] |
| Mentha × piperita L. | Menthol (34.82–43.85%), Menthone (9.1–31.68%), Carvone (0.0–19.54%), Menthol acetate (1.64–17.4%), Anethole (0.0–9.54%), Isomenthone (4.71–8.08%), Limonene (0.86–6.9%), Menthofuran (6.8%), Eucalyptol (4.36–6.21%), 1,8-Cineole (5.6%), Pulegone (0.47–5.15%), Isomenthol acetate (4.56–4.91%), Isomenthol (0.68–3.58%), Sabine (0.0–2.5%) | [61–64] |
| Mentha pulegium L. | Pulegone (2.3–70.66%), Piperitone (0.24–38.0%), Piperitenone (1.58–33.0%), Neomenthol (11.21%), α-Terpineol (0.0–4.4%), 1,8-Cineole (0.11–4.0%), Piperitenone oxide (0.0–3.4%), Menthol (2.63–3.0%), Borneol (0.0–2.9%), Isopulegone (2.33%) | [65,66] |
| Mentha requienii Benth. | Pulegone (77.6%), Isomenthone (18.2%), Limonene (1.76%) | [67] |
| Mentha spicata L. | Pulegone (0.0–78.7%), Carvone (0.0–59.12%), Menthol (0.0–39%), Menthone (5.1–21.9%), Neomenthol (11.2%), Menthol acetate (0.0–6.9%), Dihydrocarveol (0.0–6.27%), Limonene (1.0–5.8%), 1,8-Cineole (3.0–5.42%), cis-Dihydrocarveol (0.0–4.9%), cis-Carveol (0.0–3.9%), β-Caryophyllene (0.7–2.8%), β-Mycene (0.3–2.3%) | [49,51,61,68] |
| Mentha suaveolens Ehrh. | Piperitenone oxide (0.0–87.25%), Carvone (0.0–50.59%), Pulegone (0.0–30.0%), Demelverine (0.0–43.46%), Cinerolone (0.0–38.79%), p-Cymene (0.0–35.22%), Limonene (0.0–31.25%), Piperitenone oxide (0.0–26.0%), p-Cymenol-8 (0.0–20.6%), Spathulenol (0.0–18.35%), β-Caryophyllene oxide (0.3–17.25%), α-Pharnesene (0.0–16.5%), α-Cadinol (0.09–10.69%), Calamene (0.44–10.63%), α-Cubenene (0.0–10.08%), α-Caryophyllene (2.0–9.8%), Veridiflorol (0.0–7.5%), Cubenol (0.0–7.46%), Verbenone (0.0–6.56%), δ-Fenchol (0.3–5.9%), Menthol (0.0–5.7%), Borneol (0.0–5.6%), Citronellyl acetate (0.0–5.45%), δ-Cadinene (0.0–4.89), Eucalyptol (0.0–4.21%), cis-8-Menthene (0.3–4.2%), Fenchone (0.1–3.6%), Geraniol (1.0–3.4%), γ-Muurocol (0.0–3.29%), α-Pine (0.1–2.7%), β-Caryophyllene (2.56%), cis-Carveol (2.31%), Germacrene D (0.0–2.04%) | [69–71] |
| Micromeria albanica (K. Maly) Silic | Piperitenone oxide (38.73%), Pulegone (13.43%), Piperitenone (9.72%), Piperitone (5.62%), Limonene (3.2%), α-Copaene (2.12%) | [38] |
| Essential Oil | Main Chemical Components | References |
|---------------|--------------------------|------------|
| *Moluccella spinosa* L. | α-Pinene (26.6%), Caryophyllene oxide (16.8%), β-Caryophyllene (8.6%), α-Thujene (5.9%), Nonacosane (9.5%), Heptacosane (5.3%), Ethylbenzaldehyd (3.4%), Pentacosane (2.5%), Tetracosane (2.3%), Sabinine (2.2%) | [72] |
| *Nepeta ciliaris* Benth. = *Nepeta leucophylla* Benth. | Caryophyllene oxide (14.8-26.3%), β-Caryophyllene (18.0%), β-Sesquiphellandrene (15.0%), Iridodial β-monoenol acetate (9.8%) | [43] |
| *Nepeta clarkei* Hook. f. | β-Sesquiphellandrene (22.0%), Actinidine (10.0%), Germacrene D (8.0%) | [43] |
| *Ocimum basilicum* L. | Linalool (18.0–68.0%), Methyl chavicol (0.0–57.3%), Geraniol (0.0–16.5%), 1,8-Cineole (1.4–15.1%), p-Allylanisole (0.2–13.8%), Eugenol (0.0–12.32%), Limonene (0.2–10.4%), β-Farnesene (0.0–6.3%), α-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%), β-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%), β-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%), β-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%), β-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%), β-Caryophyllene (0.0–4.5%), α-Bergamotene (0.0–4.34%), α-Cadinol (0.0–4.05%) | [44,68,73–76] |
| *Ocimum × africanum* Lour. = *Ocimum × citriodorum* | Nerol (23.0%), Geranial (15.77%), Methyl chavicol (9.45%), Linalool (9.42%), β-Bisabolenene (8.31%), β-Caryophyllene (7.8%), Geraniol (5.2%), Neral (4.93%), α-Bergamotene (3.52%), α-Bisabolene (2.29%), β-Cubecene (2.26%) | [76] |
| *Ocimum campechianum* Mill. = *Ocimum micranthum* Willd. | Eugenol (46.55%), β-Caryophyllene (11.94%), β-Elemene (9.06%), 1,8-Cineole (5.35%), β-Elemene (4.17%), Bicyclogermacrene (2.9%), cis-Ocimene (2.69%), allo-Ocimene (2.42%), α-Humulene (2.4%) | [73] |
| *Ocimum forskolei* Benth. | endo-Fenchol (31.1%), τ-Cadinol (12.2%), Fenchone (12.2%), Camphor (6.2%), Linalool (5.7%), Methyl(E)-cinnamate (5.1%), α-Bergamotene (3.1%), γ-Cadinene (2.9%), endo-Fenchyl acetate (2.8%), Linalool (2.5%) | [77] |
| *Ocimum gratissimum* L. | Eugenol (0.0–61.3%), Methyl chavicol (0.0–44.63%), Linalool (0.26–21.84%), α-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%), β-Caryophyllene (0.0–11.89%), Geraniol (0.0–21.91%), α-Bisabolene (0.0–17.19%), Camphor (0.0–21.91%) | [81–83] |
| *Ocimum majorana* L. | Carvacrol (43.26%), Thymol (21.64%), p-Cymene (13.95%), γ-Terpinene (11.28%), | [84] |
| Essential Oil               | Main Chemical Components                                                                 | References       |
|----------------------------|------------------------------------------------------------------------------------------|------------------|
| *Origanum vulgare* L.      | Pulegone (0.0–77.45%), Carvacrol (0.21–65.9%), Cymenol (0.0–58.6%), Thymol (3.7–45.22%), α-Cymene (0.0–14.33%), Terpinen-4-ol (0.03–12.55%), β-Terpineol (0.0–10.46%), p-Cymene (0.5–9.3%), γ-Terpineine (3.1–9.12%), Borneol (0.0–6.1%), α-Piine (0.0–5.1%), Menthone (0.0–4.86%), Linalool (0.0–4.8%), Sabinene (0.0–3.91%), P-Phellandrene (0.0–3.74%), β-Caryophyllene (0.0–3.7%), α-Terpineol (0.0–3.35%), Sabinene hydrate (0.0–3.31%), α-Cadinol (0.0–3.3%), α-Terpineine (1.63–3.1%), Eucalyptol (0.0–2.8%), β-OCimene (0.0–2.77%), cis-Isopulegone (2.22%), β-Mycrène (0.0–2.2%), Antiol (0.0–2.13%), Piperitone (0.0–2.13%), Germacrene D (0.0–1.23%) | [49,62,64,68,74,88–91] |
| *Pogostemon cablin* (Blanco) Benth. | Patchouli alcohol (38.3–44.52%), α-Bulnesene (0.0–13.3%), γ-Guaiene (8.89–9.6%), Pogostol (0.0–6.2%), Sacythellene (5.8%), α-Bergamotene (5.76%), Eremophiline (4.34%), β-Guaiene (3.54%), β-Caryophyllene (1.93–3.0%), Patchouline (1.8–2.77%) | [92,93] |
| *Pogostemon heyneanus* Benth. | Acetophenone (51.0%), Patchouli alcohol (14.0%), Nerolidol (5.4%), β-Piine (5.3%), Limonene (4.0%), Benzyol acetone (2.4%), β-Caryophyllene (2.0%) | [93] |
| *Premna microphylla* Turcz. | Blumenol C (49.7%), γ-Greiene (6.1%), Limonene (3.8%), α-Guaiene (3.3%), Cryptone (3.1%), α-Cyperene (2.7%), cis-14-nor-Muurol-5-en-4-one (2.4%) | [94] |
| *Rosmarinus officinalis* L. | α-Pine (5.4–37.9%), 1,8-Cineole (0.88–26.54%), Eucalyptol (0.0–24.34%), Limonene (0.0–21.7%), Camphor (2.45–21.6%), Myrcyne (0.9–20.18%), Borneol (0.0–18.08%), Bornyl acetote (0.92–14.99%), Verbenone (1.36–12.0%), Camphene (1.7–11.38%), Linalool oxide (0.10–10.8%), β-Pine (0.0–6.95%), β-Caryophyllene (0.0–6.3%), Linalool (0.0–5.32%), α-Cymene (0.0–4.43%), p-Cymene (0.0–4.43%), β-Phellandrene (0.0–3.9%), Sabinene (0.0–3.72%), γ-Cadinene (0.21–2.4%), Terpinen-4-ol (0.0–2.2%), α-Humulene (0.0–2.13%), α-Terpineine (0.0–2.13%), Germacrene D (0.0–1.23%) | [51,62,68,87,91,95–98] |
| *Salvia fruticosa* Miller | 1,8-Cineole (16.9–54.4%), Camphor (0.6–18.34%), Manool (0–11.2%), β-Thujone (0.6–9.0%), β-Pine (0.0–9.0%), Sabinene (0.0–8.6%), Viridiflorol (0.0–8.4%), β-Caryophyllene (1.53–8.3%), α-Thujone (trace–8.1%), Borneol (0.0–8.0%), Camphene (0.0–7.0%), α-Pine (1.5–6.85%), Bornyl acetate (0.0–6.8%), β-Terpineol (trace–6.7%), Myrcyne (1.3–5.2%), Caryophyllene oxide (0.0–3.9%), β-Terpiney acetate (0.0–2.2%), α-Humulene (0.16–1.5%) | [49,51,99] |
| *Salvia mirzayanii* Rech. f. and Esfand | 1,8-Cineole (41.2%), Linalool acetate (10.7%), α-Terpineyl acetate (5.7%), Myrcyne (4.7%), Geranyl acetate (3.7%), γ-Cadinene (3.3%), Linalool (2.5%), Neryl acetate (2.3%) | [100] |
| Essential Oil            | Main Chemical Components                                                                                                                                                                                                 | References   |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| *Salvia officinalis* L. | 1,8-Cineole (4.2–50.3%), Camphor (8.8–25.0%), α-Thujeone (1.2–19.9%), Viridisflorol (0.5–17.5%), β-Thujeone (0.1–9.9%), β-Pinene (0.8–7.3%), β-Caryophyllene (1.4–5.5%), Borneol (1.5–5.4%), α-Pinene (0.5–4.8%), Camphene (0.2–3.9%), Bornyl acetate (0.2–3.3%), α-Terpineol (0.0–3.1%), α-Terpenyl acetate (0.0–2.6%), α-Humulene (0.4–2.6%), α-Farnesene (0.0–2.5%), Eicosane (0.0–2.0%) | [96,101]     |
| *Salvia sclarea* L.    | Linalyl acetate (84%), Caryophyllene oxide (24.1%), Linalool (13.6%), 1H-Naphtho(2,1,6)pyran (8.6%), Sclareol (11.5%), Spathulenol (11.4%), β-Caryophyllene (5.1%)                                                                 | [85,102]     |
| *Satureja hortensis* L. | Thymol (23.12–29.0%), Carvacrol (24.5–26.5%), γ-Terpinene (20.72–22.6%), p-Cymene (6.3–9.3%), α-Terpine (2.2–2.93%), p-Cymene (6.3–9.3%), α-Terpineol (0.0–3.1%), α-Terpenyl acetate (0.0–2.6%), α-Humulene (0.4–2.6%), α-Farnesene (0.0–2.5%), Eicosane (0.0–2.0%) | [103,104]    |
| *Satureja montana* L.  | Carvacrol (47.1%), p-Cymene (9.0%), γ-Terpinene (6.1%), β-Caryophyllene (3.6%), Linalool (3.1%), Thymol (2.6%), Borneol (2.1%)                                                                                             | [68]         |
| *Satureja thymbra* L.  | Thymol (25.16–44.5%), γ-Terpinene (11.1–39.23%), p-Cymene (7.17–21.7%), Carvacrol (4.18–5.3%), Carvacrol methyl ether (0.1–3.33%), α-Terpine (1.0–3.26%), β-Caryophyllene (1.2–2.76%), Caryophyllene oxide (0.32–2.0%) | [51,105]     |
| *Stachys cretica* L.   | Germacrene D (12.9–20.3%), β-Caryophyllene (0.9–9.5%), α-Pinene (0.7–8.6%), Octacosane (0.0–7.2%), β-Pinene (1.5–6.2%), Linalyl acetate (0.0–5.2%), Nonacosane (0.4–4.9%), 9-Geranyl-p-cymene (0.0–4.9%), Heptacosane (0.3–4.8%), cis-Chrysanthenyl acetate (0.0–4.8%), β-Farnesene (3.1–4.0%), Hexadecanoic acid (1.3–3.5%), Caryophyllyl oxide (0.5–2.9%), β-Bisabolene (1.6–2.8%), Linalool (0.0–2.6%), Pentacosane (0.0–2.5%), Sesquisabinene (2.1%), Ceryl acetate (0.0–2.1%) | [106]        |
| *Stachys officinalis* (L.) Trevis  | Germacrene D (19.9%), β-Caryophyllene (14.1%), α-Humulene (7.5%), δ-Cadinene (4.0%), β-Bourbonene (3.8%), α-Seline (3.4%), γ-Murolene (3.2%), Oct-1-en-3-ol (2.9%), Caryophyllene oxide (2.5%), Hexadecanoic acid (2.4%), β-Selinene (2.1%), γ-Cadinene (2.0%), τ-Murolol (2.0%) | [107]        |
| *Stachys pubescens* Ten. | Germacrene (22.4%), δ-Cadinene (19.7%), 2,6-Octadien (11.5%), Linalool (9.7%), Limonene (6.3%), δ-Elemene (5.4%), β-Ocimene (2.8%), α-Terpine (2.7%), 2,6-Octadienal (2.1%)                              | [108]        |
| *Teucrium sauvagei* Le Houerou | β-Eudesmol (28.8%), τ-Cadinol (17.5%), α-Thujeone (8.7%), γ-Cadinene (5.6%), Sabinene (4.8%), β-Selinene (4.2%), Limonene (2.8%), γ-Selinene (2.8%), α-Selinene (2.8%), δ-Cadinene (2.2%), Terpinen-4-ol (2.2%), p-Cymene (2.0%)                      | [109]        |
| *Teucrium yemense* Dellers. | Caryophyllene oxide (4.3–20.1%), 7-epi-α-Selinene (1.3–20.1%), β-Caryophyllene (11.2–19.1%), α-Cadinol (2.0–9.5%), α-Pinene (2.3–6.6%), δ-Cadinene (0.4–6.5%), α-Humulene (4.0–6.4%), τ-Cadinol (2.0–5.7%), γ-Selinene (0.4–5.5%), τ-Murolol (0.6–4.9%), Shyobunol (0.0–4.6%), Valencene (0.0–3.7%), Ledol (0.5–3.6%), cis-Sesquisabinene hydrate (0.9–3.4%), β-Pinene (1.1–3.1%), Germacrene D-4-ol (0.0–3.1%), γ-Cadinene (0.0–2.7%), β-Selinene (0.3–2.5%), Alloaromadendrene (trace–2.2%) | [77]         |
Table 2. Cont.

| Essential Oil                        | Main Chemical Components                                                                 | References |
|--------------------------------------|----------------------------------------------------------------------------------------|------------|
| Thymbra capitata (L.) Cav. = Thymus capitatus (L.) Hoffmann. and Link = Cordiothymus capitatus (L.) Rchb.f. Solms | Carvacrol (35.6–75.0%), Thymol (0.1–29.3%), p-Cymene (5.0–21.0%), γ-Terpinene (4.0–12.3%), α-Terpinene (1.0–3.0%), β-Myrcene (0.8–3.0%), Linalool (0.5–2.9%), β-Caryophyllene (0.2–2.5%) | [51,110–112] |
| Thymbra spicata L.                   | Carvacrol (20.1–64.0%), γ-Terpinene (11.6–31.2%), p-Cymene (9.6–26.0%), α-Terpinene (1.2–10.1%), β-Myrcene (0.9–7.7%), Thujene (trace–5.2%), β-Caryophyllene (0.5–5.1%) | [51,113,114] |
| Thymus bovei Benth.                  | Geraniol (35.38%), α-Citral (20.37%), β-Citral (14.76%), Neral (7.38%), 3-Octanol (4.38%) | [115]      |
| Thymus daenensis Celak.              | Carvacrol (31.46%), α-Terpineol (22.95%), Thymol (20.2%), Camphene (6.27%), 2,6-Octadien (2.22%), Borneol (2.17%), Cyclohexanone (2.1%) | [108]      |
| Thymus kotschyanus Boiss. and Hohen. | Thymol (46.72%), Benzene (6.88%), Carvacrol (3.73%), γ-Terpinene (3.58%), β-Caryophyllene (3.39%), Linalool (2.86%), Phenol (2.61%), Borneol (2.51%), Isopropyl (2.07%) | [108]      |
| Thymus mastichina (L.)               | Thymol (44.9%), Geraniol (10.8%), γ-Terpinene (10.3%), Citronellol (8.5%), p-Cymene (7.2%) | [116,117,118] |
| Thymus nigricus Klokov et Des.-Shost. | Thymol (26.0%), Carvacrol (21.0%), γ-Terpinene (8.8%), p-Cymene (7.8%), Octan-3-one (3.9%), Camphor (3.9%), β-Bisabolene (3.0%), Borneol (2.9%), Oct-1-en-3-ol (2.0%) | [119]      |
| Thymus pulegioides L.                | Carvacrol (13.91–39.07%), Thymol (11.53–34.66%), γ-Cymene (18.72–27.06%), α-Terpinene (4.13–13.73%), Linalool (3.34–3.59%), 3-Octanone (1.05–2.67%), α-Terpinene (1.67–2.37%) | [120]      |
| Thymus schimperi Ronniger            | Thymol (52.6%), p-Cymene (15.3%), β-Caryophyllene (6.8%), Sabine hydrate (3.8%), γ-Terpinene (2.9%), Terpinen-4-ol (2.4%) | [68]       |
| Thymus serpyllum L.                  | Thymol (59.5%), γ-Terpinene (11.6%), p-Cymene (6.4%), Carvacrol methyl ether (5.9%), Carvacrol (4.9%), α-Terpinene (3.3%), β-Caryophyllene (2.3%) | [121]      |
| Thymus striatus Vahl.                | Carvacrol (3.3–70.3%), Thymol (0.6–51.8%), Borneol (0.0–40.6%), p-Cymene (2.9–38.9%), α-Cymene (0.0–31.7%), α-Terpinol (0.0–19.9%), Linalool (0.0–16.0%), γ-Terpinene (0.3–12.65%), Camphene (0.0–12.3%), 1,8-Cineole (0.0–11.3%), α-Pinene (0.2–6.1%), β-Caryophyllene (0.0–3.5%), Neomenthol (0.0–2.8%), β-Cubebeene (0.0–2.4%), Geraniol (0.0–2.32%), Menthone (0.0–2.2%) | [61,64,74,85,87,104,116,122–126] |
| Thymus vulgaris L.                   | Linalool (5.5–39.7%), Thymol (0.52–39.6%), p-Cymene (2.2–21.2%), Terpinen-4-ol (1.0–11.2%), β-Myrcene (3.0–8.6%), γ-Terpinene (7.6–7.9%), α-Terpinene (1.2–4.2%), β-Caryophyllene (1.6–3.6%), α-Pinene (0.9–3.6%), Limonene (1.7–2.6%), Carvacrol (0.08–2.4%), Terpinolene (0.2–2.0%) | [116,127] |
| Thymus zygis L.                      | Carvacrol (20.5%), 1,8-Cineole (1.5–19.61%), Bicyclogermacrene (0.0–16.2%), β-Farnesene (0.0–16.1%), Sabine hydrate (0.0–14.57%), Sclarene (0.0–10.9%), α-Pinene (0.9–9.76%), Manool (0.0–8.2%), β-Caryophyllene (3.0–6.6%), β-Caryophyllene oxide (0.0–5.83%), Limonene (0.0–4.89%), Vulgarol B (0.0–4.7%), β-Pinene (0.4–4.4%), α-Terpinyl acetate (1.2–4.21%), β-Sitosterol (3.13%), p-Cymene (0.0–3.11%), Geranyl linalool (0.0–3.1%), β-Phellandrene (0.0–3.0%), Cembrene A (0.7–2.8%), Beyrene (0.0–2.6%), β-Myrcene (trace–2.12%), γ-Elemene (2.11%), s-Cadinol (2.01%) | [51,128,129] |

Vitex agnus-castus L.
Table 2. Cont.

| Essential Oil                  | Main Chemical Components                                                                 | References              |
|-------------------------------|----------------------------------------------------------------------------------------|-------------------------|
| Zataria multiflora Boiss.     | Thymol (25.8–48.4%), Carvacrol (1.5–34.36%), Carvacrol methyl ether (0.0–28.32%), p-Cymene (2.27–13.2%), γ-Terpineol (0.5–3.69%), α-Pinene (0.02–3.13%), β-Caryophyllene (2.24–3.12%), Carvacrol acetate (0.0–2.26%), Linalool (0.9–6.52%), α-Terpinylen acetate (5.4%), α-Terpineol (0.0–28.32%), Carvacrol methyl ether (0.92–10.6%), Linalool (0.0–2.21%) | [117,130]               |
| Ziziphora clinopodioides L.   | Carvacrol (0.63–74.29%), Thymol (7.28–55.6%), γ-Terpineol (1.54–24.56%), p-Cymene (2.21–10.25%), α-Terpinene (0.0–2.26%) | [131,132]               |
| Ziziphora tenuior L.          | Pulegone (46.8%), p-Menth-3-en-8-ol (12.5%), Isomenthone (6.6%), 8-Hydroxymenthone (6.2%), Isomenthol (4.7%), Limonene (3.2%) | [133]                   |

To the chemical components most commonly found as the main ingredients in essential oils, among plants presented in Table 2, include β-caryophyllene (41 plants), linalool (27 plants), limonene (26), β-pinene (25), 1,8-cineole (22), carvacrol (21), α-pinene (21), p-cymene (20), γ-terpinene (20), and thymol (20) (Figure 2). Sesquiterpene β-caryophyllene seems particularly important antifungal component in the Lamiaceae family. Its activity and its derivatives, such as caryophyllene oxide is well known [134–136]. According to Bona et al. [137], essential oils containing high concentrations of phenolic monoterpenes (e.g., carvacrol, p-cymene, thymol) have great antifungal activities. Rich in these substances are, among others Origanum and Thymus plants. Important antifungal chemicals often presented in Lamiaceae are also other monoterpenes as alcohol linalool and cyclic 1,8-cineole, limonene, pinenes, and terpinenes [138–146]. Table 1 shows that all of these antifungal substances are common in presented plants.

![β-caryophyllene](image1)

![linalool](image2)

![α-pinene](image3)

![β-pinene](image4)

![1,8-cineole](image5)

![limonene](image6)
Figure 2. Chemical formulas of ten substances the most commonly found in essential oils of Lamiaceae plants presented in Table 1.

3. Antifungal Activity of Essential Oils of Lamiaceae Family

In Table 3 are shown the antifungal activities of selected Lamiaceae essential oils. More than half of the essential oils have good activity (<1000 µg/mL) against fungi. In some cases are observed significant discrepancies between different studies. An example could be the action of essential oils from Italian Calamintha nepeta against Candida albicans. In the work of Marongiu et al. [39], minimal inhibitory concentrations amounted to 1.25–2.5 µg/mL, while in Božović et al. [40] MICs were between 780 to 12,480 µg/mL. Differences may be related to the different biochemical composition of the examined essential oils. In results presented by Marongiu et al. [39] the main components of essential oils were pulegone (39.9–64.4%), piperitenone oxide (2.5–19.1%) and piperitenone (6.4–7.7%), while in Božović et al. [40] three main substances were pulegone (37.7–84.7%), crysanthenone (1.3–33.9%) and menthone (0.5–35.4%). Some authors have described that the content of active substances varies depending on the season. In studies of Gonçalves et al. [60] in Mentha cervina during the flowering phase in August amount of isomenthone and pulegone in essential oil amounted 8.7% and 75.1% respectively. Simultaneously, in the vegetative phase in February, the content of both components changed significantly and amounted to 77.0% for isomenthone and 12.9% for pulegone. Similarly, Al-Maskri et al. [75] presented essential changes in some compounds of Ocimum basilicum essential oil between winter and summer. In the summer essential oil, there is significantly more of linalool, p-allylanisole and β-farnesene, and at the same time much less content of limonene and 1,8-cineole. In this work, a seasonal variation of chemical composition is directly related to other antifungal activities. It is particularly evident in action against Aspergillus niger, which was lower in the summer season. Zone of growth inhibition (ZOI) for winter essential oil was 21 mm and MIC > 50 µg/mL, while for summer essential oil-ZOI was 13 mm and MIC > 100 µg/mL [75]. Influence on the content of chemical substances in essential oils also has a method of obtaining them. Čavar et al. [40] compared the composition of oils obtained from Calamintha glandulosa using three methods: Hydrodistillation (HD), steam distillation (SD) and aqueous reflux extraction (ARE). For example, the level of menthone was 3.3% in ARE, 4.7% in HD, and 8.3% in SD method, while for shisofuran was only 0.1% in HD and SD, and even 9.7% in ARE [40]. Additionally, many other factors can affect antimicrobial activity, such as amount and concentration of inoculum, type of culture medium, pH of the medium and incubation time. All these factors can affect the value of MIC [145]. Differences are visible in Table 2. Generally, it can be assumed that the best activity (MICs < 100) have essential oils from Clinopodium spp. (excluding C. nepeta subsp. glandulosum and C. umbrosum), Lavandula spp., Mentha spp. (excluding M. piperita), Thymbra spp., and Thymus spp. (excluding T. migricus and T. vulgaris). The highest values of MICs are
presented among others for *Aeollanthus suaveolens*, *Agastache rugosa*, *Lepechinia mutica*, *Mentha × piperita*, and *Salvia sclarea*. Simultaneously, some essential oils have a very different activity, and MIC values differ depending on the region, chemical composition, research methodology, etc. Significant variations can be observed even in *Ocimum basilicum* (MICs 1–10,000), *O. sanctum* (MICs 0.1–500), *Origanum majorana* (MICs 0.5–14,400) or in *Thymus vulgaris* (MICs 0.08–3600).

The mode of action of essential oils is multidirectional. Essential oils lead to disruption of the cell wall and cell membrane through a permeabilization process. The lipophilic compounds of essential oils can pass through the cell wall and damage polysaccharides, fatty acids, and phospholipids, eventually making them permeable [146,147]. Change of the permeability for H⁺ and K⁺ cations affects cellular pH and damage of cellular organelles [148,149]. Additionally, essential oils inhibit the synthesis of fungal DNA, RNA, proteins, and polysaccharides [150]. Essential oils can also disintegrate mitochondrial membrane [151,152]. It has also been shown that essential oil from *Thymus vulgaris* inhibits the production of aflatoxins by *Aspergillus flavus* and leads to the reduction of ergosterol production [123].

| Table 3. Minimal inhibitory concentrations (MICs) of essential oils against fungi. |
|-------------------------------|---------------------------------|-----------------|
| **Source of the Essential Oil** | **Targeted Fungus**              | **MICs (µg/mL; µl/mL)** | **Reference(s)** |
| *Aeollanthus suaveolens* Mart. ex Spreng. = *A. heliotropioides* Oliv. | *Candida albicans*               | 1200–5000        | [34] |
|                               | *Candida glabrata*               | 5000             | [34] |
|                               | *Candida krusei*                 | 2500             | [34] |
|                               | *Candida parapsilosis*           | 2500             | [34] |
|                               | *Candida tropicalis*             | 1200             | [34] |
|                               | *Cryptococcus neoformans*        | 600–5000         | [34] |
|                               | *Aspergillus flavus*             | 10,000           | [153] |
|                               | *Aspergillus niger*              | 5000             | [153] |
|                               | *Blastoschizomyces capitatus*    | 5000             | [153] |
|                               | *Candida albicans*               | 28–5000          | [153,154] |
|                               | *Candida utilis*                 | 5000             | [153] |
|                               | *Candida tropicalis*             | 5000             | [153] |
|                               | *Cryptococcus neoformans*        | 10,000           | [153] |
|                               | *Trichoderma viride*             | 5000             | [153] |
|                               | *Trichophyton erinacei*          | 780              | [153] |
|                               | *Trichophyton mentagrophytes*    | 3120             | [153] |
|                               | *Trichophyton rubrum*            | 150              | [153] |
|                               | *Trichophyton schoenleinii*      | 1560             | [153] |
|                               | *Trichophyton soudanense*        | 1560             | [153] |
|                               | *Trichophyton tonsurans*         | 10,000           | [153] |
|                               | *Trichosporon mucoides*          | 5000             | [153] |
| *Agastache rugosa* (Fisch. and C.A.Mey.) Kuntze | *Alternaria solani*              | 750              | [37] |
|                               | *Botrytis cinerea*               | 600              | [37] |
|                               | *Fusarium coeruleum*             | 350              | [37] |
|                               | *Fusarium culmorum*              | 300              | [37] |
|                               | *Fusarium oxysporum*             | 300              | [37] |
|                               | *Fusarium solani*                | 350              | [37] |
|                               | *Fusarium sporotrichioides*      | 350              | [37] |
|                               | *Fusarium tabacinum*             | 350              | [37] |
|                               | *Fusarium verticillioides*       | 300              | [37] |
| *Ballota nigra* subsp. foetida (Vis.) Hayek | *Aspergillus niger*              | 0.4              | [38] |
|                               | *Aspergillus ochraceus*          | 0.4              | [38] |
|                               | *Cladosporium cladosporioides*   | 0.4              | [38] |
|                               | *Fusarium tricinctum*            | 0.4              | [38] |
|                               | *Penicillium ochrachromogenes*   | 0.4              | [38] |
|                               | *Phomopsis helianthi*            | 0.2              | [38] |
|                               | *Trichoderma viride*             | 0.4              | [38] |
| *Clinopodium dalmaticum* (Benth.) Bräuchler and Heubl = *Micromeria dalmatica* Benth. | *Aspergillus niger*              | 1250             | [39] |
|                               | *Aspergillus ochraceus*          | 0.4              | [38] |
|                               | *Fusarium tricinctum*            | 0.4              | [38] |
|                               | *Penicillium ochrachromogenes*   | 0.4              | [38] |
|                               | *Phomopsis helianthi*            | 0.2              | [38] |
|                               | *Trichoderma viride*             | 0.4              | [38] |
| *Clinopodium nepeta* subsp. glanduloum* (Req.) *Govaria = Calamintha glandulosa* (Req.) Bentham = *Calamintha officinalis* Moench | *Aspergillus niger*              | 1250             | [39] |
|                               | *Candida albicans*               | 2500             | [39] |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µL/mL) | Reference(s) |
|----------------------------|----------------|--------------------|--------------|
| Clinopodium nepeta (L.) Kuntze = Calamintha nepeta (L.) Savi | Aspergillus fumigatus | 0.64–5 | [41] |
| | Aspergillus niger | 0.32–10 | [41] |
| | Candida albicans | 1.25–12,480 | [41,42] |
| | Candida guilliermondii | 1.25–2.5 | [41] |
| | Candida kruzei | 1.25–2.5 | [41] |
| | Candida parapsilosis | 1.25–2.5 | [41] |
| | Candida tropicalis | 1.25–2.5 | [41] |
| | Cryptococcus neoformans | 0.32–1.25 | [41] |
| | Epidermophyton floccosum | 0.64–2.5 | [41] |
| | Microsporum canis | 0.64–2.5 | [41] |
| | Microsporum gypseum | 1.25–5 | [41] |
| | Trichophyton mentagrophytes | 0.64–5 | [41] |
| | Trichophyton rubrum | 0.64–5 | [41] |
| Clinopodium thymifolium (Scop.) Kuntze = Micromeria thymifolia (Scop.) Fritsch | Aspergillus niger | 2 | [38] |
| | Aspergillus ochraceus | 2 | [38] |
| | Cladosporium cladosporioides | 2 | [38] |
| | Fusarium tricinctum | 2 | [38] |
| | Penicillium ochrochloron | 0.4 | [38] |
| | Phomopsis helianthi | 0.4 | [38] |
| | Trichoderma viride | 2 | [38] |
| Clinopodium umbrosum (M.Bieb.) Kuntze = Calamintha umbrosa Benth. | Alternaria solani | 3000 | [43] |
| | Fusarium oxysporum | 2000 | [43] |
| | Helminthosporium maquidis | 1500 | [43] |
| | Alternaria solani | 625 | [155] |
| | Candida albicans | 625–1000 | [44,155] |
| | Epidermophyton floccosum | 2500 | [155] |
| | Fusarium semitectum | 313 | [155] |
| Hymenocrater longiflorus Benth. | Aspergillus niger | 480 | [45] |
| | Candida albicans | 240 | [45] |
| Hyptis ovalifolia Benth. | Microsporum canis | 15.6–1000 | [46,156] |
| | Microsporum gypseum | 7.8–1000 | [46,156] |
| | Trichophyton mentagrophytes | 15.6–1000 | [46,156] |
| | Trichophyton rubrum | 7.8–1000 | [46,156] |
| | Aspergillus niger | 52,200 | [47] |
| | Aspergillus ochraceus | 26,100 | [47] |
| | Aspergillus versicolor | 10,440 | [47] |
| | Candida albicans | 128–1000 | [44,48] |
| | Candida glabrata | 512–1024 | [48] |
| | Candida kruzei | 128–256 | [48] |
| | Candida parapsilosis | 256–512 | [48] |
| | Candida tropicalis | 512–1024 | [48] |
| | Cladosporium cladosporioides | 10,440 | [47] |
| | Cladosporium fulvum | 26,100 | [47] |
| | Penicillium fumiculosum | 52,200 | [47] |
| | Penicillium ochrochloron | 26,100 | [47] |
| | Trichoderma viride | 10,440 | [47] |
| Lavandula angustifolia Mill. | Candida albicans | 0.125–512 | [50,51,157] |
| | Malassezia furfur | >4 | [49] |
| | Trichophyton rubrum | 1–512 | [49,51] |
| | Trichosporon beigeli | 2 | [49] |
| Lavandula multifida L. | Aspergillus fumigatus | 0.32 | [52] |
| | Aspergillus niger | 0.32 | [52] |
| | Candida albicans | 0.32 | [52] |
| | Candida guilliermondii | 0.32 | [52] |
| | Candida kruzei | 0.64 | [52] |
| | Candida parapsilosis | 0.32 | [52] |
| | Candida tropicalis | 0.32 | [52] |
| | Cryptococcus neoformans | 0.16 | [52] |
| | Epidermophyton floccosum | 0.16 | [52] |
| | Microsporum canis | 0.16 | [52] |
| | Microsporum gypseum | 0.16 | [52] |
| | Trichophyton mentagrophytes | 0.16 | [52] |
| | Trichophyton mentagrophytes var. interdigitale | 0.16 | [52] |
| | Trichophyton rubrum | 0.16 | [52] |
| | Trichophyton verrucosum | 0.16 | [52] |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus               | MICs (µg/mL; µl/mL) | References(s) |
|-----------------------------|-------------------------------|---------------------|---------------|
| **Lavandula pedunculata (Miller) Cav.** |                               |                     |               |
|                             | Aspergillus flavus            | 5–10                | [53]          |
|                             | Aspergillus fumigatus         | 2.5–5               | [53]          |
|                             | Aspergillus niger             | 5                   | [53]          |
|                             | Candida albicans              | 2.5                 | [53]          |
|                             | Candida guillermondii         | 1.25                | [53]          |
|                             | Candida kruzie               | 1.25–2.5            | [53]          |
|                             | Candida parapsilosis          | 2.5–5               | [53]          |
|                             | Candida tropicalis            | 1.25–2.5            | [53]          |
|                             | Cryptococcus neoformans       | 0.32–1.25           | [53]          |
|                             | Epidermophyton floccosum      | 0.32–0.64           | [53]          |
|                             | Microsporum canis             | 0.32–1.25           | [53]          |
|                             | Microsporum gypseum           | 0.64–2.5            | [53]          |
|                             | Trichophyton mentagrophytes   | 0.64–1.25           | [53]          |
|                             | Trichophyton rubrum           | 0.32–1.25           | [53]          |
|                             | *Trichophyton mentagrophytes var. interdigitale* | 0.16–0.64 | [54] |
|                             | *Trichophyton rubrum*         | 0.16–256            | [51,54]       |
|                             | *Trichophyton verrucosum*     | 0.32                | [54]          |
| **Lavandula stoechas L.**    |                               |                     |               |
|                             | Aspergillus flavus            | 1.25–10             | [54]          |
|                             | Aspergillus fumigatus         | 0.64–1.25           | [54]          |
|                             | Aspergillus niger             | 0.32–1.25           | [54]          |
|                             | Candida albicans              | 0.64–512            | [53,54]       |
|                             | Candida guillermondii         | 1.25                | [54]          |
|                             | Candida kruzie               | 2.5                 | [54]          |
|                             | Candida parapsilosis          | 2.5                 | [54]          |
|                             | Candida tropicalis            | 2.5                 | [54]          |
|                             | Cryptococcus neoformans       | 0.64                | [54]          |
|                             | Epidermophyton floccosum      | 0.16–0.32           | [54]          |
|                             | Microsporum canis             | 0.16–0.64           | [54]          |
|                             | Microsporum gypseum           | 0.32–0.64           | [54]          |
|                             | Trichophyton mentagrophytes   | 0.32–0.64           | [54]          |
|                             | *Trichophyton mentagrophytes var. interdigitale* | 0.16–0.64 | [54] |
|                             | *Trichophyton rubrum*         | 0.16–256            | [51,54]       |
|                             | *Trichophyton verrucosum*     | 0.32                | [54]          |
| **Lavandula viridis L’Her.** |                               |                     |               |
|                             | Aspergillus flavus            | 5                   | [55]          |
|                             | Aspergillus fumigatus         | 2.5                 | [55]          |
|                             | Aspergillus niger             | 2.5                 | [55]          |
|                             | Candida albicans              | 1.25–2.5            | [55]          |
|                             | Candida guillermondii         | 0.64–1.25           | [55]          |
|                             | Candida kruzie               | 1.25–2.5            | [55]          |
|                             | Candida parapsilosis          | 2.5                 | [55]          |
|                             | Candida tropicalis            | 1.25–2.5            | [55]          |
|                             | Cryptococcus neoformans       | 0.64                | [55]          |
|                             | Epidermophyton floccosum      | 0.32                | [55]          |
|                             | Microsporum canis             | 0.32                | [55]          |
|                             | Microsporum gypseum           | 0.64                | [55]          |
|                             | Trichophyton mentagrophytes   | 0.32–0.64           | [55]          |
|                             | *Trichophyton mentagrophytes var. interdigitale* | 0.32–0.64 | [55] |
|                             | *Trichophyton rubrum*         | 0.32                | [55]          |
|                             | *Trichophyton verrucosum*     | 0.32                | [55]          |
| **Lepechinia mutica (Benth.) Epling** |                               |                     |               |
|                             | Candida albicans              | >9000               | [56]          |
|                             | Fusarium graminearum          | >9000               | [56]          |
|                             | Microsporum canis             | 2200–4500           | [56]          |
|                             | Pyricularia oryzae            | >9000               | [56]          |
|                             | Trichophyton rubrum           | 2200–4500           | [56]          |
| **Marrubium vulgare L.**     |                               |                     |               |
|                             | Aspergillus niger             | >1180               | [58]          |
|                             | Botrytis cinerea              | >1100               | [58]          |
|                             | Fusarium solani               | >1190               | [58]          |
|                             | Penicillium digitatum         | >1120               | [58]          |
| **Melissa officinalis L.**   |                               |                     |               |
|                             | Aspergillus niger             | 313                 | [59,158]      |
|                             | Candida albicans              | 30–313              | [59,158]      |
|                             | Cryptococcus neoformans       | 78                  | [158]         |
|                             | Epidermophyton floccosum      | 30                  | [59]          |
|                             | Microsporum canis             | 30                  | [59]          |
|                             | Penicillium verrucosum        | 125                 | [159]         |
|                             | Trichophyton mentagrophytes var. interdigitale | 15                  | [59] |
|                             | *Trichophyton rubrum*         | 15                  | [59]          |
|                             | *Trichophyton tonsurans*      | 15                  | [59]          |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | Reference(s) |
|-----------------------------|----------------|---------------------|--------------|
| Mentha cervina L.           | Aspergillus flavus | 2.5–5               | [60]         |
|                             | Aspergillus fumigatus | 1.25–2.5          | [60]         |
|                             | Aspergillus niger   | 1.25–2.5            | [60]         |
|                             | Candida albicans    | 1.25–2.5            | [60]         |
|                             | Candida guilliermondii | 1.25–2.5        | [60]         |
|                             | Candida kruzei      | 1.25–2.5            | [60]         |
|                             | Candida parapsilosis| 1.25–2.5            | [60]         |
|                             | Candida tropicalis  | 1.25–2.5            | [60]         |
|                             | Cryptococcus neoformans | 1.25              | [60]         |
|                             | Epidermophyton floccosum | 0.64–1.25    | [60]         |
|                             | Microsporum canis   | 1.25                | [60]         |
|                             | Microsporum gypseum | 1.25–2.5            | [60]         |
|                             | Trichophyton mentagrophytes | 1.25–2.5   | [60]         |
|                             | Trichophyton rubrum  | 1.25                | [60]         |

| Mentha × piperita L.        | Aspergillus flavus | 1450–5000           | [62,64]      |
|                             | Aspergillus niger  | 625–10,000          | [64,158]     |
|                             | Aspergillus parasiticus | 2500              | [64]         |
|                             | Candida albicans    | 225–1125            | [63,158,160] |
|                             | Candida glabrata    | 225                 | [62]         |
|                             | Candida tropicalis  | 225–230             | [62]         |
|                             | Cryptococcus neoformans | 313                | [158]        |
| Mentha pulegium L.          | Fusarium oxysporum | 125                 | [161]        |
|                             | Penicillium chrysogenum | 1250             | [64]         |
|                             | Penicillium minioluteum | 2090–2200       | [62]         |
|                             | Penicillium oxalicum | 1300–2050          | [62]         |
|                             | Penicillium verrucosum | 2500             | [90]         |

| Mentha × piperita L.        | Aspergillus niger  | 0.25–1.25           | [65,66,162]  |
|                             | Aspergillus flavus | 1.25                | [162]        |
|                             | Aspergillus fumigatus | 1.25              | [162]        |
|                             | Candida albicans    | 0.94–3.75           | [65,66,162]  |
|                             | Candida brasarensis | 3.75              | [163]        |
|                             | Candida guilliermondii | 1.25             | [162]        |
|                             | Candida kruzei      | 0.94–1.25           | [162,163]    |
|                             | Candida parapsilosis| 1.25                | [162]        |
|                             | Candida tropicalis  | 1.25                | [162]        |
|                             | Cryptococcus neoformans | 0.64            | [162]        |
|                             | Epidermophyton floccosum | 1.25          | [162]        |
|                             | Microsporum canis   | 1.25                | [162]        |
|                             | Microsporum gypseum | 1.25–2.5            | [162]        |
|                             | Saccharomyces cerevisiae | <0.3–0.94      | [66,163]     |
|                             | Trichophyton mentagrophytes | 1.25–2.5   | [162]        |
|                             | Trichophyton mentagrophytes var. interdigitale | 2.5      | [162]        |
|                             | Trichophyton rubrum  | 1.25                | [162]        |
|                             | Trichophyton verrucosum | 1.25           | [162]        |

| Mentha requienii Bentham   | Alternaria spp.    | >40                 | [67]         |
|                             | Aspergillus fumigatus | >60               | [67]         |
|                             | Candida albicans    | 0.94–40             | [67,163]     |
|                             | Candida brasarensis | 3.75                | [163]        |
|                             | Candida kruzei      | 0.94                | [163]        |
|                             | Fusarium spp.       | >40                 | [67]         |
|                             | Penicillium spp.    | >60                 | [67]         |
|                             | Rhodotorula spp.    | 45                  | [67]         |
|                             | Saccharomyces cerevisiae | 0.94           | [163]        |

| Mentha spicata L.          | Aspergillus flavus | 1.25                | [162]        |
|                             | Aspergillus fumigatus | 0.64              | [162]        |
|                             | Aspergillus niger   | 0.64–313            | [51,158,162] |
|                             | Candida albicans    | 1.25–625            | [51,158,162] |
|                             | Candida guilliermondii | 1.25              | [162]        |
|                             | Candida kruzei      | 1.25                | [162]        |
|                             | Candida parapsilosis| 1.25                | [162]        |
|                             | Candida tropicalis  | 1.25                | [162]        |
|                             | Cryptococcus neoformans | 0.32–313       | [158,162]    |
|                             | Epidermophyton floccosum | 0.64           | [162]        |
|                             | Fusarium graminearum | 2.5              | [164]        |
|                             | Fusarium moniliforme | 2.5               | [164]        |
|                             | Malassezia furfur   | >4                  | [49]         |
|                             | Microsporum canis   | 0.64–2              | [68,162]     |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µL/mL) | Reference(s) |
|-----------------------------|-----------------|---------------------|---------------|
|                             | Microsporum gypseum | 0.64–3             | [162]         |
|                             | Penicillium corylophilum | 0.625             | [165]         |
|                             | Penicillium expansum | 2.5                | [164]         |
|                             | Trichophyton erinacei | 3                  | [68]          |
|                             | Trichophyton mentagrophytes | 0.64–3           | [66,162]      |
|                             | Trichophyton mentagrophytes var. interdigitale | 0.64 | [162] |
|                             | Trichophyton rubrum | 0.25–512           | [49,51,162]   |
|                             | Trichophyton terrestre | 3               | [68]          |
|                             | Trichophyton verrucosum | 0.32              | [162]         |
|                             | Trichosporon beigelii | 0.25              | [162]         |
| Mentha suaveolens Ehrh.     | Candida albicans | 0.34–1250          | [69,71,166]   |
|                             | Candida glabrata | 0.69–2.77          | [69]          |
|                             | Cryptococcus neoformans | 300              | [167]         |
|                             | Microsporum canis | 1250               | [167]         |
|                             | Microsporum gypseum | 1250              | [167]         |
|                             | Trichophyton mentagrophytes | 600–1250       | [167]         |
|                             | Trichophyton rubrum | 5000               | [167]         |
|                             | Trichophyton violaceum | 600              | [167]         |
| Micromeria alba (Griseb. ex K. Maly) Silic | Aspergillus niger | 0.2                | [38]          |
|                             | Aspergillus ochraceus | 0.2               | [38]          |
|                             | Cladosporium cladosporioides | 0.2       | [38]          |
|                             | Fusarium tricinctum | 0.4                | [38]          |
|                             | Penicillium ochrochloron | 0.2            | [38]          |
|                             | Phomopsis helianthi | 0.2                | [38]          |
|                             | Trichoderma viride | 0.4                | [38]          |
| Moluccella spinosa L.       | Aspergillus niger | 50                  | [72]          |
|                             | Candida albicans | 100                 | [72]          |
|                             | Fusarium oxysporum | 100                | [72]          |
| Nepeta ciliaris Benth. = Nepeta leucophylla Benth. | Alternaria solani | 3000               | [43]          |
|                             | Candida albicans | 0.78               | [168]         |
|                             | Fusarium oxysporum | 1000               | [43]          |
|                             | Trichophyton rubrum | 0.19               | [168]         |
|                             | Helminthosporium maudis | 1500               | [43]          |
| Nepeta clarkei Hook. f.     | Alternaria solani | 3000               | [43]          |
|                             | Fusarium oxysporum | 2000               | [43]          |
|                             | Helminthosporium maudis | 2000           | [43]          |
| Ocimum basilicum L.         | Aspergillus flavus | 10,000              | [64]          |
|                             | Aspergillus fumigatus | >50               | [75]          |
|                             | Aspergillus niger | >50–10,000         | [64,75,158]   |
|                             | Aspergillus parasiticus | 5000           | [64]          |
|                             | Candida albicans | 30–625             | [73,74,158]   |
|                             | Candida guilliermondii | 3.125–6.25     | [76]          |
|                             | Cryptococcus neoformans | 313–1250       | [158,169]    |
|                             | Debaryomyces Hansenii | 6.25             | [76]          |
|                             | Epidermophyton floccosum | 15               | [74]          |
| Ocimum × africanum Lour. = Ocimum × citriodorum | Microsporum canis | 1–15.2             | [68,74]       |
|                             | Penicillium glaucum | 10,000             | [64]          |
|                             | Penicillium italicum | >50               | [75]          |
|                             | Rhizopus stolonifer | >50               | [75]          |
|                             | Rhizotorula glutinis | 86               | [73]          |
|                             | Trichophyton erinacei | 2.5              | [68]          |
|                             | Trichophyton mentagrophytes | 2.5–8.3        | [68,74]       |
|                             | Trichophyton terrestre | 3                | [68]          |
|                             | Saccharomycodes cerevisiae | 28              | [73]          |
|                             | Schizosaccharomyces pombe | 86              | [73]          |
|                             | Trichophyton rubrum | 8.3                | [74]          |
|                             | Trichophyton tomsorans | 8               | [74]          |
|                             | Verruca lypellytica | 57                 | [73]          |
| Ocimum × africanum Lour. = Ocimum × citriodorum | Candida guilliermondii | 3.125          | [76]          |
|                             | Debaryomyces Hansenii | 1.56             | [76]          |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | References |
|----------------------------|-----------------|---------------------|------------|
| Ocimum campechianum Mill. = Ocimum micranthum Willd. | Candida albicans | 69 [73] | |
| | Rhodotorula glutinis | 139 [73] | |
| | Saccharomyces cerevisiae | 69 [73] | |
| | Schizosaccharomyces pombe | 104 [73] | |
| | Varronia hypolitica | 69 [73] | |
| Ocimum forskolei Benth. | Candida albicans | 35.3–8600 [77,170] | |
| | Aspergillus fumigatus | >1000 [78] | |
| | Candida albicans | 350–1500 [76,171] | |
| | Candida kruziei | 750 [171] | |
| | Candida parapsilosis | 380 [171] | |
| | Candida tropicalis | 1500 [171] | |
| | Cryptococcus neoformans | 250–300 [78,79] | |
| | Fusarium oxysporum f. sp. cubense | 62.5 [80] | |
| | Fusarium oxysporum f. sp. hypoperosu | 31.25 [80] | |
| Ocimum gratissimum L. | Fusarium oxysporum f. sp. trachepileum | 62.5 [80] | |
| | Fusarium solani | 62.5 [80] | |
| | Macrophomina phaseolina | 62.5–125 [80] | |
| | Malassezia pachydermatis | 300 [78] | |
| | Microsporum canis | 200–500 [78,172] | |
| | Microsporum gypseum | 150–250 [78,172] | |
| | Rhizoctonia solani | 31.25 [80] | |
| | Scopulariopsis brevicaulis | 400 [78] | |
| | Trichophyton interdigital | 250 [78] | |
| | Trichophyton mentagrophytes | 200–250 [78,172] | |
| | Trichophyton rubrum | 150–250 [78,172] | |
| Ocimum tenuiflorum L. = Ocimum sanctum L. | Aspergillus flavus | 300 [83] | |
| | Candida albicans | 0.1–300 [81,82] | |
| | Candida glabrata | 0.15–300 [81,82] | |
| | Candida kruziei | 0.35–450 [81,82] | |
| | Candida parapsilosis | 0.25–500 [81,82] | |
| | Candida tropicalis | 0.1–300 [81,82] | |
| Origanum compactum Benth. | Alternaria alternata | 300 [84] | |
| | Bipolaris orieae | 300 [84] | |
| | Fusarium equiseti | 300 [84] | |
| | Fusarium graminearum | 300 [84] | |
| | Fusarium verticillioides | 300 [84] | |
| Origanum majorana L. | Aspergillus flavus | 450–650 [62] | |
| | Aspergillus niger | 625 [158] | |
| | Botrytis cinerea | 5000 [87] | |
| | Candida albicans | 625 [158] | |
| | Cryptococcus neoformans | 313 [158] | |
| | Fusarium delphinioides | 1800–14,400 [85] | |
| | Fusarium incarnatum-equiseti | 450–3600 [85] | |
| | Fusarium napsiforme | 3600–14,400 [85] | |
| | Fusarium oxysporum | 900–3600 [85] | |
| | Fusarium solani | 900–3600 [85] | |
| | Fusarium verticillioides | 14,400 [85] | |
| | Microsporum canis | 0.5 [68] | |
| | Microsporum gypseum | 2 [68] | |
| | Penicillium expansum | 10,000 [87] | |
| | Penicillium minioluteum | 400–500 [62] | |
| | Penicillium oxalicum | 350–400 [62] | |
| | Spathothrix brasiliensis | ≤2250–9000 [86] | |
| | Spathothrix scheeckii | ≤2250–9000 [86] | |
| | Trichophyton erinacei | 1 [68] | |
| | Trichophyton mentagrophytes | 1.5 [68] | |
| | Trichophyton terrestre | 2 [68] | |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus       | MICs (µg/mL; µl/mL) | References(s) |
|-----------------------------|-----------------------|--------------------|---------------|
| Pogostemon cablin (Blanco) Benth. | Aspergillus flavus | 0.32–0.64 | [62,89,91] |
|                             | Aspergillus fumigatus | 0.32–0.64 | [62,89,91,158] |
|                             | Aspergillus niger     | 0.32–0.623 | [62,89,91,158] |
|                             | Aspergillus ochraceus  | 470    | [91] |
|                             | Aspergillus parasiticus | 2500   | [64] |
|                             | Candida albicans      | 0.32–700 | [74,88,89,91,158] |
|                             | Candida glabrata      | 350    | [88] |
|                             | Candida guillermondii | 0.64–1–2.5 | [89] |
|                             | Candida krusei        | 0.64–700 | [88,89] |
|                             | Candida parapsilosis  | 0.64–170 | [88,89] |
|                             | Candida tropicalis    | 0.32–700 | [88,89] |
|                             | Cladosporium sp.      | 0.05–0.3 | [173] |
|                             | Cryptococcus neoformans | 0.16–78 | [89,158] |
|                             | Epidermophyton floccosum  | 0.32–2 | [74,89] |
|                             | Fusarium sp.          | 0.1–0.5 | [173] |
|                             | Malassezia furfur     | 1–780   | [49,174] |
|                             | Microsporum canis     | 0.025–1.25 | [68,74,89] |
|                             | Microsporum gypseum   | 0.025–4.125 | [68,89] |
|                             | Penicillium chrysogenum | 625     | [64] |
|                             | Penicillium corphophylum | 0.625  | [165] |
|                             | Penicillium funiculosum | 610    | [91] |
|                             | Penicillium ochrochloron | 710    | [91] |
|                             | Penicillium verrucosum | 1.1719 | [90,158] |
|                             | Trichophyton mentagrophytes | 0.32–1.25 | [74,89] |
|                             | Trichophyton rubrum   | 0.16–1.25 | [74,89,89] |
|                             | Trichophyton tonsurans | 1       | [74] |
|                             | Trichophyton beigelii | 0.25   | [49] |
|                             | Trichophyton erinacei | 0.5    | [68] |
|                             | Trichophyton mentagrophytes | 0.5     | [68] |
|                             | Trichophyton terrestre | 0.25   | [68] |
| Pogostemon heyneanus Benth. | Candida albicans      | 6000   | [176] |
|                             | Candida glabrata      | 6000   | [176] |
|                             | Candida tropicalis    | 10,000 | [176] |
| Premna microphylla Turcz.   | Aspergillus niger     | >500   | [94] |
|                             | Candida albicans      | >500   | [94] |
|                             | Fusarium oxysporum    | >500   | [94] |
| Rosmarinus officinalis L.   | Aspergillus flavus    | 330    | [91] |
|                             | Aspergillus fumigatus | 590    | [91] |
|                             | Aspergillus ochraceus  | 380–10,000 | [91,98,158] |
|                             | Botrytis cinerea      | 2500   | [87] |
|                             | Candida albicans      | 30.2–1000 | [51,91,96,98,158] |
|                             | Cryptococcus neoformans | 313    | [158] |
|                             | Epidermophyton floccosum  | 30     | [96] |
|                             | Microsporum canis     | 2.5–30.2 | [68,96] |
|                             | Microsporum gypseum   | 2.5    | [68] |
|                             | Penicillium expansum  | 5000   | [87] |
|                             | Penicillium ochrochloron | 470    | [91] |
|                             | Penicillium funiculosum | 570    | [91] |
|                             | Trichophyton erinacei | 1.5    | [68] |
|                             | Trichophyton mentagrophytes | 5–15.3 | [68,96] |
|                             | Trichophyton rubrum   | 15–256 | [51,96] |
|                             | Trichophyton terrestre | 5      | [68] |
|                             | Trichophyton tonsurans | 15.2   | [96] |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | References(s) |
|----------------------------|-----------------|---------------------|---------------|
| **Salvia fruticosa Miller** | **Candida albicans** | 512 [51] | |
| **Fusarium oxysporum f. sp. dianthi** | >2000 [99] | | |
| **Fusarium proliferatum** | >2000 [99] | | |
| **Salvia mirzayanii Rech. f. and Esfand** | **Candida albicans** | 0.5–2 [100] | |
| **Candida krusei** | 1 [100] | | |
| **Candida dubliensis** | 0.06–0.5 [100] | | |
| **Candida glabrata** | 0.06–1 [100] | | |
| **Candida parapsilosis** | 0.25–4 [100] | | |
| **Candida tropicalis** | 0.25–2 [100] | | |
| **Trichosporon beigeli** | 1 [49] | | |
| **Salvia officinalis L.** | **Aspergillus flavus** | 5–10 [101] | |
| **Aspergillus fumigatus** | 2.5–5 [101] | | |
| **Aspergillus niger** | 5–1250 [101,158] | | |
| **Candida albicans** | 2.5–2780 [96,101,158,177] | | |
| **Candida guilliermondii** | 1.25–2.5 [101] | | |
| **Candida krusei** | 2.5–5 [101] | | |
| **Candida parapsilosis** | 5 [101] | | |
| **Candida tropicalis** | 1.25 [101] | | |
| **Cryptococcus neoformans** | 0.64–625 [101,158] | | |
| **Epidermophyton floccosum** | 0.64–100 [96,101] | | |
| **Microsporum canis** | 1.25–100.2 [96,101] | | |
| **Microsporum gypseum** | 1.25–2.5 [101] | | |
| **Trichophtyon mentagrophes** | 1.25–60 [96,101] | | |
| **Trichophyton mentagrophes var. interdigital** | 1.25 [101] | | |
| **Trichophyton rubrum** | 0.64–60 [96,101] | | |
| **Trichophyton tonsurans** | 60 [96] | | |
| **Trichophyton verrucosum** | 1.25–2.5 [101] | | |
| **Salvia sclarea L.** | **Aspergillus niger** | 1250 [158] | |
| **Candida albicans** | 1250 [158] | | |
| **Cryptococcus neoformans** | 313 [158] | | |
| **Fusarium delphinoides** | 1800–3600 [85] | | |
| **Fusarium incanumatum-equiseti** | 1800–3600 [85] | | |
| **Fusarium moniliforme** | 1800–3600 [85] | | |
| **Fusarium oxysporum** | 1800–3600 [85] | | |
| **Fusarium solani** | 3600–7200 [85] | | |
| **Fusarium verticillioides** | 1800 [85] | | |
| **Salvia scabra L.** | **Alternaria alternata** | 62.5 [103] | |
| **Aspergillus flavus** | 31.25–500 [103,104,117] | | |
| **Aspergillus niger** | 471 [117] | | |
| **Aspergillus ochraceus** | 423 [117] | | |
| **Aspergillus parasiticus** | 373 [117] | | |
| **Aspergillus terreus** | 389 [117] | | |
| **Satureja hortensis L.** | **Aspergillus variecolor** | 125 [103] | |
| **Candida albicans** | 200–400 [103,178] | | |
| **Fusarium culmorum** | 125 [103] | | |
| **Fusarium oxysporum** | 250 [103] | | |
| **Microsporum canis** | 62.5 [103] | | |
| **Monilinia fructicola** | 31.25 [103] | | |
| **Penicillium spp.** | 125 [103] | | |
| **Rhizoctonia solani** | 125 [103] | | |
| **Rhizopus spp.** | 250 [103] | | |
| **Sclerotinia minor** | 250 [103] | | |
| **Sclerotinia sclerotiorum** | 125 [103] | | |
| **Trichophyton mentagrophes** | 62.5 [103] | | |
| **Trichophyton rubrum** | 31.25 [103] | | |
| **Satureja montana L.** | **Microsporum canis** | 0.5 [68] | |
| **Microsporum gypseum** | 2 [68] | | |
| **Trichophyton erinacei** | 2 [68] | | |
| **Trichophyton mentagrophes** | 2 [68] | | |
| **Trichophyton terrestris** | 3 [68] | | |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | References(s) |
|-----------------------------|-----------------|---------------------|---------------|
| *Satureja thymbra* L.       | Aspergillus flavus | 25 [105]           |               |
|                             | Aspergillus fumigatus | 1.25–25 [105,179] |               |
|                             | Aspergillus niger | 2.5–25 [105,179]    |               |
|                             | Aspergillus ochraceus | 2.5–25 [105,179]  |               |
|                             | Aspergillus versicolor | 1.25 [179]       |               |
| Candida albicans            | 25–128 [51,105]  |                     |               |
| Penicillium funiculosum     | 2.5–25 [105,179] |                     |               |
| Penicillium ochrochloron    | 1–2.5 [105,179]   |                     |               |
| Trichoderma viride         | 1.25–25 [105,179] |                     |               |
| Trichophyton rubrum        | 128 [51]         |                     |               |
| *Stachys cretica* L.       | Candida albicans | 625 [106]          |               |
| *Stachys officinalis* (L.) Trevis | Aspergillus niger | 2500 [107]        |               |
|                             | Candida albicans | 5000 [107]         |               |
| *Stachys pubescens* Ten.   | Alternaria alternata | 1 [108]          |               |
|                             | Aspergillus flavus | 0–5 [108]         |               |
|                             | Fusarium oxyporum | 1 [108]           |               |
| *Teucrium sauvagei* Le Houerou | Aspergillus fumigatus | >1000 [109]     |               |
|                             | Candida albicans | >1000 [109]        |               |
|                             | Cryptococcus neoformans | >1000 [109]   |               |
|                             | Epidermophyton floccosum | 850 [109] |               |
|                             | Microsporum canis | 800 [109]          |               |
|                             | Microsporum gypseum | 900 [109]         |               |
|                             | Scopulariopsis brevicaulis | >1000 [109] |               |
|                             | Scytalidium dimidiatum | >1000 [109]   |               |
| Trichophyton mentagrophytes var. interdigitale | 950 [109] | | |
| Trichophyton mentagrophytes var. mentagrophytes | 900 [109] | | |
|                             | Trichophyton rubrum | 800 [109]         |               |
|                             | Trichophyton soudanense | 800 [109]    |               |
| *Teucrium yemense* Defflers. | Aspergillus niger | 313 [77]          |               |
|                             | Botrytis cinerea | 313 [77]           |               |
|                             | Candida albicans | 1250 [77]          |               |
| *Thymbra capitata* (L.) Cav. = *Thymus capitatus* (L.) Hoffmanns. and Link = Cordelthybus capitatus (L.) Rchb.f. Solms | Aspergillus flavus | 0.32 [111] | |
|                             | Aspergillus fumigatus | 0.16–0.32 [111] | |
|                             | Aspergillus niger | 0.1–0.16 [111,180] | |
|                             | Aspergillus oryzae | 0.2 [180]          |               |
| Candida albicans            | 0.16–128 [51,110–112] | | |
| Candida glabrata            | 0.32 [111,112]    |                     |               |
| Candida guillermondii       | 0.16–0.32 [111,112] | | |
| Candida kruzei              | 0.32 [111]        |                     |               |
| Candida leporidis           | 0.32 [111,112]    |                     |               |
| Candida tropicalis          | 0.32 [111,112]    |                     |               |
| Epidermophyton floccosum    | 0.08 [111]        |                     |               |
| Fusarium solani             | 0.2 [180]         |                     |               |
| Microsporum canis           | 0.08 [111]        |                     |               |
| Microsporum gypseum         | 0.08 [111]        |                     |               |
| Penicillium digitatum       | 0.5 [180]         |                     |               |
| Trichophyton mentagrophytes | 0.08 [111]        |                     |               |
| Trichophyton rubrum         | 0.16–64 [51,111]  |                     |               |
| *Thymbra spicata* L.        | Aspergillus fumigatus | 0.3 [179]        | |
|                             | Aspergillus niger | 0.6 [179]          |               |
|                             | Aspergillus versicolor | 0.3 [179]      |               |
|                             | Aspergillus ochraceus | 0.6 [179]      |               |
| Candida albicans            | 1.12–3750 [51,113,114] | | |
| Candida kruzei              | 1.12 [114]        |                     |               |
| Candida parapsilosis        | 0.32 [111,112]    |                     |               |
| Candida tropicalis          | 0.32 [111,112]    |                     |               |
| Epidermophyton floccosum    | 0.08 [111]        |                     |               |
| Fusarium solani             | 0.2 [180]         |                     |               |
| Microsporum canis           | 0.08 [111]        |                     |               |
| Microsporum gypseum         | 0.08 [111]        |                     |               |
| Penicillium digitatum       | 0.5 [180]         |                     |               |
| Trichophyton mentagrophytes | 0.08 [111]        |                     |               |
| Trichophyton rubrum         | 0.16–64 [51,111]  |                     |               |
| *Thymus borei* Benth.       | Candida albicans | 250 [115]          |               |
| *Thymus daenensis* Celak.   | Alternaria alternata | >8 [108]         |               |
|                             | Aspergillus flavus | 1 [108]           |               |
|                             | Fusarium oxyporum | 4 [108]           |               |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | References(s) |
|-----------------------------|-----------------|---------------------|---------------|
| Thymus kotechnus Boiss. and Hohen. | Alternaria alternata | 1 | [108] |
|  | Aspergillus flavus | 0.5 | [108] |
|  | Fusarium oxysporum | 0–5 | [108] |
|  | Candida albicans | 1.25–2.5 | [116] |
|  | Candida glabrata | 1–2.5 | [116] |
|  | Candida guilliermondii | 1.25 | [116] |
|  | Candida krusei | 1.25–2.5 | [116] |
|  | Candida parapsilosis | 2–5 | [116] |
|  | Candida tropicalis | 2.5–10 | [116] |
|  | Aspergillus flavus | 0.32–0.64 | [119] |
|  | Aspergillus niger | 0.16 | [181] |
|  | Aspergillus tubingensis | 0.08–0.31 | [181] |
|  | Epidermophyton floccosum | 0.08 | [181] |
|  | Microsporum canis | 0.025 | [68] |
|  | Microsporum gypseum | 0.128–1 | [120] |
|  | Penicillium chrysogenum | 0.512–2 | [120] |
|  | Phomopsis helianthi | 0.5 | [121] |
|  | Trichoderma viride | 0.1 | [121] |
|  | Trichophyton mentagrophytes | 0.1 | [68] |
|  | Trichophyton terrestris | 0.1 | [68] |
| Thymus mastichina (L.) L. | Candida albicans | 1.25 | [108] |
|  | Aspergillus flavus | 0.5 | [108] |
|  | Fusarium oxysporum | 0–5 | [108] |
|  | Thymus mastichina (L.) L. | Candida albicans | 1.25 | [116] |
|  | Aspergillus flavus | 1 | [108] |
|  | Aspergillus niger | 1.5 | [121] |
|  | Aspergillus ochraceus | 1 | [121] |
|  | Aspergillus terreus | 1 | [121] |
|  | Aspergillus versicolor | 1 | [121] |
|  | Cladosporium cladosporioides | 0.5 | [121] |
|  | Epidermophyton floccosum | 0.08 | [181] |
|  | Microsporum canis | 0.025 | [68] |
|  | Microsporum gypseum | 0.512–2 | [120] |
|  | Penicillium chrysogenum | 0.025 | [68] |
|  | Phomopsis helianthi | 0.5 | [121] |
|  | Trichoderma viride | 2 | [121] |
|  | Trichophyton mentagrophytes | 1 | [68] |
| Thymus nigricus Klokov et Des.-Shost. | Aspergillus flavus | 452 | [117] |
|  | Aspergillus niger | 460 | [117] |
|  | Aspergillus ochraceus | 430 | [117] |
|  | Aspergillus parasiticus | 581 | [117] |
|  | Aspergillus terreus | 447 | [117] |
| Thymus pulegioides L. | Aspergillus flavus | 1–4 | [120] |
|  | Aspergillus niger | 0.128–1 | [120] |
|  | Candida albicans | 0.32–0.64 | [119] |
|  | Candida glabrata | 0.32–0.64 | [119] |
|  | Candida guilliermondii | 0.32 | [119] |
|  | Candida krusei | 0.32–0.64 | [119] |
|  | Candida tropicalis | 0.32–0.64 | [119] |
|  | Epidermophyton floccosum | 0.16 | [119] |
|  | Microsporum canis | 0.16 | [119] |
|  | Microsporum gypseum | 0.16 | [119] |
|  | Microsporum gypseum | 0.128–1 | [120] |
|  | Penicillium chrysogenum | 0.512–2 | [120] |
|  | Rhodotorula spp. | 0.08 | [181] |
|  | Trichophyton spp. | 0.08–0.31 | [181] |
|  | Verticillium sp. | 0.512–2 | [120] |
|  | Thymus schimperi Ronninger | Aspergillus flavus | 0.16 | [121] |
|  | Aspergillus niger | 0.128–1 | [120] |
|  | Aspergillus ochraceus | 0.08 | [181] |
|  | Microsporum canis | 0.025 | [68] |
|  | Microsporum gypseum | 0.512–2 | [120] |
|  | Penicillium chrysogenum | 0.025 | [68] |
|  | Verticillium sp. | 0.512–2 | [120] |
|  | Thymus serpyllum L. | Aspergillus carbonarius | 1.25 | [182] |
|  | Aspergillus ochraceus | 0.625 | [182] |
|  | Aspergillus niger | 2.5 | [182] |
|  | Microsporum canis | 0.025 | [68] |
|  | Microsporum gypseum | 0.25 | [68] |
|  | Trichophyton erinacei | 0.1 | [68] |
|  | Trichophyton mentagrophytes | 0.2 | [68] |
|  | Trichophyton terrestris | 0.1 | [68] |
|  | Alternaria alternata | 1 | [121] |
|  | Aspergillus flavus | 1.5 | [121] |
|  | Aspergillus niger | 1 | [121] |
|  | Aspergillus ochraceus | 1 | [121] |
|  | Aspergillus terreus | 1 | [121] |
|  | Aspergillus versicolor | 1 | [121] |
|  | Cladosporium cladosporioides | 0.5 | [121] |
|  | Epidermophyton floccosum | 0.128–1 | [120] |
|  | Microsporum canis | 0.025 | [68] |
|  | Microsporum gypseum | 0.512–2 | [120] |
|  | Penicillium chrysogenum | 0.025 | [68] |
|  | Verticillium sp. | 0.512–2 | [120] |
|  | Thymus striatus Vahl. | Phomopsis helianthi | 0.5 | [121] |
|  | Trichoderma viride | 2 | [121] |
|  | Trichophyton mentagrophytes | 1 | [121] |
Table 3. Cont.

| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | References(s) |
|-----------------------------|------------------|---------------------|----------------|
| Thymus vulgaris L.          |                  |                     |                |
| Thymus zygis L.             |                  |                     |                |
| Candida albicans            | 0.16–0.32        | [116]               |                |
| Candida glabrata            | 0.16             | [116]               |                |
| Candida krusei              | 0.08–0.16        | [116]               |                |
| Candida guillermondii       | 0.16             | [116]               |                |
| Candida parapsilosis        | 0.16–0.32        | [116]               |                |
| Candida tropicalis          | 0.16–0.32        | [116]               |                |
| Chaetomium globosum         | 1.6              | [122]               |                |
| Cladosporium spp.           | 12.8             | [122]               |                |
| Cladosporium sphaerospermum | 19.6             | [122]               |                |
| Cryptococcus neoformans     | 78               | [122]               |                |
| Epidermophyton floccosum    | 4                | [74]                |                |
| Fusarium spp.               | 62.5             | [185]               |                |
| Fusarium delphinoide        | 900–1800         | [85]                |                |
| Fusarium incarnatum-equiseti | 450–3600      | [85]                |                |
| Fusarium napiforme          | 900              | [85]                |                |
| Fusarium oxysporum          | 5–900            | [85,126]            |                |
| Fusarium solani             | 1800–3600        | [85]                |                |
| Fusarium verticillioides    | 900              | [85]                |                |
| Malassezia furfur           | 920              | [174]               |                |
| Microsporum canis           | 2.2              | [74]                |                |
| Mortierella spp.            | 250              | [185]               |                |
| Mucor spp.                  | 50.2 ± 8.4       | [122]               |                |
| Penicillium spp.            | 18.95–500        | [122,185]           |                |
| Penicillium brevicompactum  | 19.6             | [122]               |                |
| Penicillium chrysogenum     | 312.5–1750       | [64,184]            |                |
| Penicillium chrysogenum     | 19.6             | [122]               |                |
| Penicillium citrusum        | 1250             | [184]               |                |
| Penicillium expansum        | 625              | [87]                |                |
| Penicillium griseofulvum    | 19.6             | [122]               |                |
| Rhizopus spp.               | 12.6             | [122]               |                |
| Rhodotorula glutinis        | 72               | [73]                |                |
| Saccharomyces cerevisae     | 72               | [73]                |                |
| Schizosaccharomyces pombe   | 36               | [73]                |                |
| Stachybotrys chartarum      | 6.2              | [122]               |                |
| Trichoderma spp.            | 16.8             | [122]               |                |
| Trichophyton mentagrophytes | 2.2              | [74]                |                |
| Trichophyton rubrum         | 2–72             | [74,124]            |                |
| Trichophyton tonsurans      | 2.2              | [74]                |                |
| Ulocladium spp.             | 5.45 ± 1.5       | [122]               |                |
| Yarrowia lipolytica         | 36               | [73]                |                |
| Candida albicans            | 0.16–0.32        | [116]               |                |
| Candida glabrata            | 0.32             | [116]               |                |
| Candida krusei              | 0.16–0.32        | [116]               |                |
| Candida guillermondii       | 0.16             | [116]               |                |
| Candida parapsilosis        | 0.32             | [116]               |                |
| Candida tropicalis          | 0.16–0.32        | [116]               |                |
| Penicillium corylophilum    | 0.3125–0.625     | [165]               |                |
| Source of the Essential Oil | Targeted Fungus | MICs (µg/mL; µl/mL) | Reference(s) |
|----------------------------|-----------------|--------------------|--------------|
| Vitex agnus-castus L.      | Candida albicans | 0.53–512           | [51,129]     |
|                            | Candida dubliniensis | 0.27               | [129]        |
|                            | Candida famata    | 2.13               | [129]        |
|                            | Candida glabrata  | 0.27               | [129]        |
|                            | Candida krusei    | 0.27               | [129]        |
|                            | Candida lusitaniae| 2.13               | [129]        |
|                            | Candida parapsilosis | 1.06              | [129]        |
|                            | Candida tropicalis| 0.13               | [129]        |
|                            | Epidermophyton floccosum | 0.64–2.5           | [128]        |
|                            | Microsporum canis | 0.64–5             | [128]        |
|                            | Microsporum gypseum | 1.25–10            | [128]        |
|                            | Trichophyton mentagrophytes | 1.25–10           | [128]        |
|                            | Trichophyton rubrum | 0.64–512          | [51,128]     |
| Zataria multiflora Boiss.   | Aspergillus flavus | 358                | [117]        |
|                            | Aspergillus niger | 358                | [117]        |
|                            | Aspergillus ochraceus | 341             | [117]        |
|                            | Aspergillus parasiticus | 367        | [117]        |
|                            | Aspergillus terreus | 447              | [117]        |
|                            | Microsporum canis | 0.125–0.25        | [130]        |
|                            | Microsporum gypseum | 0.03–0.06         | [130]        |
|                            | Trichophyton mentagrophytes | 0.03–0.06    | [130]        |
|                            | Trichophyton rubrum | 0.03–0.06         | [130]        |
|                            | Trichophyton schoenleini | 0.125–0.6 | [130]        |
| Ziziphora clinopodioides Lam. | Aspergillus flavus | 48.82              | [184,186]    |
|                            | Aspergillus fumigatus | 1750          | [184]        |
|                            | Aspergillus niger | 3000              | [184]        |
|                            | Aspergillus ochraceus | 1500            | [184]        |
|                            | Aspergillus parasiticus | 48.82       | [186]        |
|                            | Penicillium chrysogenum | 3000        | [184]        |
|                            | Penicillium citrinum | 1750            | [184]        |
| Ziziphora tenuior L.       | Aspergillus flavus | 1.25              | [133]        |
|                            | Aspergillus fumigatus | 0.64            | [133]        |
|                            | Aspergillus niger | 0.64              | [133]        |
|                            | Candida albicans  | 1.25              | [133]        |
|                            | Candida guillermondii | 1.25          | [133]        |
|                            | Candida krusei    | 1.25              | [133]        |
|                            | Candida parapsilosis | 1.25         | [133]        |
|                            | Candida tropicalis| 1.25              | [133]        |
|                            | Cryptococcus neoformans | 0.16        | [133]        |
|                            | Epidermophyton floccosum | 0.64       | [133]        |
|                            | Microsporum canis | 0.64–1.25        | [133]        |
|                            | Microsporum gypseum | 1.25            | [133]        |
|                            | Trichophyton mentagrophytes | 1.25   | [133]        |
|                            | Trichophyton mentagrophytes var. interdigitale | 1.254 | [133] |
|                            | Trichophyton rubrum | 0.64             | [133]        |
|                            | Trichophyton verrucosum | 0.64        | [133]        |

4. Essential Oils of Lamiaceae Plants in Cosmetics and Medicines

Some essential oils of Lamiaceae family plants and/or their components are commonly used in cosmetics and less often in medicine. Essential oils from *Thymus vulgaris*, *Origanum vulgare*, *Rosmarinus officinalis*, *Calamintha officinalis*, *Salvia officinalis*, or *Lavandula officinalis* are in cosmetic formulations as natural preservatives [187]. *Lavandula angustifolia* oil is commonly used as a fragrance in cosmetics, soaps, perfumes and pharmaceutical products. It also acts as an anti-inflammatory, and is calming, headache relieving, is a sedative and is skin healing. Essential oils from *Lavandula hybridra* and *L. angustifolia* also have anti-louse activity. Compounds (essential oils and mainly menthol) extracted from *Mentha piperita* are commonly used as a fragrance in soaps, cosmetics and as well as in the kitchen as a spice and refreshing products. Moreover, they are often found in chewing gums, toothpastes, and mouthwashes. For medical use, it can be taken orally in gastrointestinal complications. *Rosmarinus officinalis* essential oil is often an ingredient as a fragrance in cosmetics, soaps, bath salts and oils, gels and ointments. It is widely used for hair care and hair-loss treatment because it promotes hair growth and helps against dandruff [188]. In medicine, essential oils from Lamiaceae family are used in
aromatherapy (Salvia sclarea, Lavandula officinalis, Mentha piperita, Rosmarinus officinalis) [189], sinusitis (Lavandula officinalis, Thymus vulgaris) [190], and in upper respiratory tract for treatment of catarrh (Mentha piperita, Mentha arvensis, Thymus spp.) [191]. Both essential oils from Lamiaceae plants and mono-substances are used in toothpastes and mouthwashes. In many of these the following chemicals, like limonene, linalool, menthol, and thymol, are presented as flavorings and fragrances [192,193]. Additionally, in some toothpastes are essential oils, e.g., in “Parodontax®” occurs Salvia officinalis oil, Mentha piperita oil, and Mentha arvensis oil; in “Lacalut Active Herbal” is Mentha arvensis oil, Thymus vulgaris oil, and Salvia officinalis oil, while in “Signal Family Herbal Fresh” are oils from Mentha piperita and Salvia officinalis [194]. Literature data confirm a strong antifungal effect against C. albicans and anti-inflammatory activity of “Parodontax” toothpaste [195,196]. Besides toothpastes, also some medicines used to rinse the oral cavity or throat contain a large number of essential oils. Mention may be made of “Salviasept” having in its composition the oils from Mentha × piperita, Thymus vulgaris, Thymus zygis, Origanum majorana, and Salvia officinalis or “Dentosept Complex” containing oils from Mentha piperita, Thymus vulgaris, Salvia sp., Lavandula sp., and Eucalyptus globulus. Among the antifungal medicines in “Acerin Talk” antifungal foot deodorant are present Lavandula sp. oil, menthol, linalool, limonene, and geraniol, while in “Podoflex Tincture” for nails mucosis occur among others oils from Salvia sclarea and Lavandula angustifolia and mono-substances current in Lamiaceae plants: geraniol, limonene, linalool, citral, and eugenol [194].

5. Conclusions

More than half of the essential oils from Lamiaceae family plants have good antifungal activity (MICs < 1000 µg/mL). The microbiological data indicate that they could be used alone or in combination with antifungal drugs in the treatment of fungal infections, especially of the skin and mucous membranes. Some essential oils and their components extracted from Lamiaceae plants are used in cosmetics and medicines. Essential oils may be of future relevance in the treatment of multi-drug resistant fungi.

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