Antibacterial and antifungal activities of medicinal plant species and endophytes

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**ABSTRACT**
Systemic bacterial and fungal infections in recent years due to the increasing number of debilitating diseases immune system such as AIDS, blood malignancies, overdose, corticosteroid drugs, and broad-spectrum antibiotics has been raised. There is a prevalence of acute and subsequent candida infections with drug-resistance properties such as fluconazole. Due to the prevalence and spread of fungal and bacterial diseases, the effort to find treatments has increased more than before. The use of plant compounds for the therapy of fungal and bacterial diseases is effective due to their unique biocompatible and bioavailable. The trend toward new antifungal and antibacterial agents being introduced to the market remains small, while resistance to many antibiotics is emerging, especially in patients receiving long-term treatment. Considering the enormous antimicrobial potentials of natural compounds isolated from plants and endophytes and screening of new antibiotics for various pharmaceutical applications as an alternative source remains largely unknown. Endophytes and medicinal plant species have main primary and secondary metabolites suitable to hindrance or inactivation of pathogens. Recently, various studies about the antibacterial and antifungal activities of these metabolites have been reported. For this purpose, in this review, antibacterial and antifungal activities of endophytes of *Pestalotiopsis* genus and medicinal plant species of *Zingiber* and *Hydnora* genera have been discussed according to recent studies.

**1. Introduction**
Systemic bacterial and fungal infections in recent years due to the increasing number of debilitating diseases immune system such as AIDS, blood malignancies, overdose, corticosteroid drugs, broad-spectrum antibiotics specifically in the case of multidrug-resistant bacteria, etc. [1-4], especially for hospitalized patients has been raised. For instance, there is a prevalence of acute and subsequent candida infections with drug-resistance properties such as fluconazole [5]. Therefore, it is a critical affair to apply alternative effective compounds in particular, primary and various secondary metabolites of medicinal plants (carotenoids, alkaloids, phenolic compounds, and flavonoids; Figure 1a) [6], and fungal endophytes [7] (Figure 1b) for treatment and prevention of fungal and bacterial infections without side effects of antibiotics [8, 9].

**2. The endophytic fungus**

**2.1. Pestalotiopsis**

As mentioned in the introduction section, endophytes can contribute to their host plant species by producing various metabolites to protect and survive the plant [10]. In addition, the main function of this endophyte can be to produce a variety of biologically active...
molecules and new metabolites in medicine, agriculture and industrial complexes that have a variety of micro and nano applications \[11-14\].

The recurrence of fungal infections encountered during allogeneic bone marrow transplantation, cancer treatment and organ transplantation has necessitated the discovery of more efficient and better compatible antifungal compounds. There are a very limited number of antifungal compounds in action against various forms of local and systemic fungal infections \[15, 16\]. Pestalotiopsis is an important genus of an ascomycete, and several species of this genus have been identified to produce biologically active compounds for various biological properties, including antimicrobial, antifungal,
antiviral, anti-cancer, and antioxidant activities [17].

Some studies reported antifungal metabolites of this genus include a new lactone monoterpenes, (3R, 4R, 6R, 7S) -7-hydroxy-3,7-dimethyl-oxabicyclo nonan-2-one, with a combination A known related 3 R, 4R-3- (7-methyl cyclohexenyl) -propanoic acid) was discovered from the endophytic fungus Pestalotiopsis foedan obtained from Bruguiera sexangula, a mangrove tree or shrub, in Hainan. These compounds showed antifungal activity against Botrytis cinerea and Phytophthora nicotianae at minimum inhibition concentration (MIC) values of 3.1 and 6.3 μg/ml, while the known antifungal drug, ketoconazole showed comparable activity (MIC 3.1 μg/ml). The effects of Candida albicans at MIC 50 μg/ml show positive efficacy while ketoconazole MIC at 6.3 μg/ml has positive efficacy [18].

3. Plants

3.1. Zingiber genus

Zingiber cassumunar Roxb. belongs to the Zingiberaceae family and is a perennial herbaceous plant that consists of an underground part consisting of rhizomes. In Thailand, Indonesia and other Asian countries, Z. cassumunar is traditionally used as a medicinal plant in folk remedies, for example, to treat various diseases such as inflammation, including arthritis, rheumatism, sprains, Respiratory problems such as asthma and cough and pain due to musculoskeletal disorders, menstruation or gastrointestinal tract are main medicinal applications of these plants [19].

Various types of compounds found in Z. cassumunar such as phenylbutenoids, curcuminoinds, sesquiterpenoids, benzaldehydes, quinones and essential oils containing monoterpenoids have been identified that are used in the treatment of many of these diseases. Phenylbutenoids are characteristic compounds of this plant and have been isolated using various separation techniques, including silica gel or reverse phase column chromatography, recrystallization, and thin-layer chromatography. Extracts and compounds of Z. cassumunar have activities, biologically diverse, including antioxidant activity [20].

In addition to inflammation, anti-cancer, neuroprotective/neurotrophic, cosmetic, and antifungal/antibacterial activities, a review of the clinical effects of various formulations using Plai (Z. cassumunar) on pain relief, acne treatment, and antihistamines has been performed. But there has been no previous report summarizing the accumulated studies in the phytochemicals literature and the in vitro and in vivo biological properties of Z. cassumunar, including our previous studies that have contributed to the discovery of chemical diversity and biological activity of this plant [21]. The oil of Z. cassumunar rhizomes has high antifungal activity (inhibition zone of 11.7-15.7 mm) and its effectiveness is much higher than the five strains of yeast, Saccharomyces cerevisiae, Cryptococcus neoformans, C. albicans, and Candida tropicalis [22].

Z. cassumunar essential oil, containing 32% volume of terpinene-4-1 as its main constituent, showed antibacterial activity against a wide range of bacteria Gram-positive: Staphylococcus aureus ATCC 29737, Streptococcus pyogenes, Bacillus subtilis ATCC28663, Propionibacterium acne; Gram-negative: Escherichia coli ATCC 10536, Salmonella typhi, Pseudomonas aeruginosa ATCC 25619, Klebsiella pneumoniae ATCC 10031, and Proteus vulgaris with a minimum concentration of (2 to 2.2%) bactericidal activity (6.2 to 2%) and antifungal activity against Epidermophyton floccosum, Microsporum gypseum, Trichophyton mentagrophytes, Trichophyton rubrum and yeasts (C. albicans and Cryptococcus neoformans) by oil provided the minimum fungicidal concentration of 0.3% [23].

Ginger (Z. montanum) essential oil contains sabine (C_{10}H_{18}), terpinene-4-1 (9.0-31.3%), and terpinene as the main components against eight pathogenic bacteria (Gram-positive: S. aureus MTCC 96, S. epidermidis MTCC 435 and Streptococcus mutans MTCC 890 were evaluated; Gram-negative: Klebsiella pneumoniae MTCC 109, P. aeruginosa MTCC 741, E. coli MTCC 723, E. coli DH5a, and Salmonella MTC 98 and showed good
antibacterial activity with minimum inhibitory concentration values in the range of 1025 μg/ml, indicating the lowest rate for *S. typhimurium*. The oil also showed antifungal activity (250 μg/ml) against two fungal strains (*C. albicans* ATCC 14053 and *C. albicans* MTCC 1637) [24].

### 3.2. **Camellia genus**

Many studies have shown the health benefits of several species of camellia, namely *C. sinensis*, *C. oleifera* and *C. japonica*. These species have antimicrobial (antibacterial, antifungal, and antiviral) and antitumor activity and are a huge source of polyphenols such as catechins. (Especially epicatechin (EC), epigallocatechin (EGC), epicatechin-3-gallate (ECG) and especially epigallocatechin-3-gallate (EGCG), the main polyphenols of green, white, and black tea [25].

Brew tea and shoot germ tea, two extracts of Turkish black tea, have been reported to be ineffective against *C. albicans*, one of the most opportunistic pathogens, as well as against other microorganisms [26]. In 2010, it was concluded that the methanolic extract of green tea leaf (*C. sinensis*) had no activity against the two species of *Aspergillus*. Both studies involved four distinct concentrations of the extract, which somewhat Reinforces their conclusions [27].

The popularity of *C. sinensis* has received a great deal of attention because of its byproduct, tea, which completely overshadows the remaining species of camellia, and few studies have been devoted to them. In 2013, Feás et al. studied the activity of virgin oils of *C. oleifera*, *C. reticulata* and *C. sasanqua* seeds against clinical strains of *C. albicans*. These three oils showed antifungal activity that showed different MICs [28].

### 3.3. **Hydnora genus**

The genus Hydnora (Hydnoraceae) is one of the basic angiosperms in the order Piperales, which is found in the semi-arid regions of Africa and the South Arabian Peninsula. As various studies have shown, plants in this genus play an essential role in communities around the world. There are currently eight species of the genus Hydnora. Seven genera are in Africa and one in *Arabian Peninsula* [29].

Hydnoraceae are grouped under the family Aristolochiaceae and include parasitic plants characterized by large, leafless flowers. They are native to the arid and semi-arid regions of Africa and Asia. Tannins have been used in local communities in Africa and the Arabian Peninsula. In Uganda, Sudan and Kenya, some species of *Hydnora* are used as food sources and to treat various ailments. *H. abyssinica* decoction is used as a medicine for inflammation, tonsillitis and dysentery in Sudan [30].

In Oman, *H. abyssinica* fruits are used as food and in leather tanning. In eastern Ethiopia, this plant (*H. abyssinica*) is used to treat diarrhea, bleeding, ulcers and oral infections. In addition, *H. abyssinica* flowers are used as wild food and in traditional medicine in South Yemen [31]. Among its therapeutic properties, antibacterial, antifungal, and antioxidant activities have been reported in *H. abyssinica* and *H. africana*. Regardless of the ethnic botanical value and medicinal importance of Hydnora, little effort has been made to integrate all relevant data [32].

### 4. Conclusion

Due to the prevalence and spread of fungal and bacterial diseases, the effort to find treatments has increased more than before. The application of plant compounds for treatment of fungal and bacterial diseases can be effective due to their unique biocompatible and bioavailable. All the compounds related to *Pestalotiopsis*, *Zingiber*, and *Hydnora* have shown a positive effect in killing a group of fungal and bacterial pathogens and are the suitable options instead of chemical drugs.

### Conflict of Interests

The author declares no conflict of interest.

### Ethics approval and consent to participate

No human or animals were used in the present research.
Consent for publications
The author read and approved the final manuscript for publication.

Availability of data and material
All the data were embedded in the manuscript.

Informed Consent
The author declares not to use any patients in this research.

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References


