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Journal of Pharmaceutics and Pharmacology Research

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Review Article

The endophytic fungi pestalotiopsis what's for it and what's on it?

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Received date: January 25, 2021; Accepted date: January 28, 2021; Published date: February 04, 2021

Citation: Waill A. Elkhateeb, Ghoson M. Daba (2021) The endophytic fungi pestalotiopsis what's for it and what's on it. J. Pharmaceutics and Pharmacology Research 4(1); DOI: 10.31579/2693-7247/032

Abstract

Fungi generally and endophytic ones specifically represent future factories and potent biotechnological tools for production of bioactive natural substances, which could extend healthy life of humanity. *Pestalotiopsis* is a fungal genus that belongs to family; Sporocadaceae, has been known as a promising secondary metabolites producer. However the same fungus showed harmful pathogenicity against different plants causing crops economical losses. This review is to demonstrate secondary metabolites from the endophytic fungi *Pestalotiopsis* and some of its reported biological activities. Moreover, describing the unique chemical diversity of this fungal genus involved in medical, pharmaceutical, agricultural applications. Also highlight the harmful side of this important fungus.

Keyword: pestalotiopsis; endophytic fungi; secondary metabolites

Introduction

Endophytic fungi have rich source of secondary metabolites which act as biological active agent in the higher plants. The fungal derivatives play vital part in human life and their compounds are the source of drug for cancer, microbial and other applications. Some secondary metabolites originated from endophytes have growth inhibiting activities against many plant pathogens. Endophytes are rich sources of natural products which are used in agriculture (plant growth), pharmaceutical industries and also used for phytoremediation [1, 2]. Endophytic fungi isolated from medicinal plants show variation in types of valuable compounds, and potency in their activity [3, 4]. Compare to other endophytic microorganisms, fungal endophytes produce large number of secondary activities [5]. Fungal endophytes derivatives are used in biotechnological applications. It has a wide significance in pharmaceutical science because of its antimicrobial, anticancer and other activities [6, 7].

Fungal endophytes are attracting escalating attention by researchers due to their ability to secrete various, structurally novel products, which nominates them as promising candidates for drug discovery. *Pestalotiopsis* is one of the famous fungal genera known for its generosity in production and accumulation of various biologically active compounds [8-10].

Most resent researches on *Pestalotiopsis* is based on endophytic isolates and has resulted in isolation and identification four new species. These are *Pestalotiopsis hainanensis*, *Pestalotiopsis jesteri*, *Pestalotiopsis kunmingensis* and *Pestalotiopsis pallidotheae* [11-13]. *Pestalotiopsis* genus showing promising bioremediation potential for waste reduction and taxol production, which have important application as anticancer agent [14, 15].

Pestalotiopsis description and ecology

Based on the conidial forms, Steyaert [16, 17] split *Pestalotia* into three genera, namely *Pestalotia*, *Pestalotiopsis* and *Truncatella*. *Pestalotiopsis* genus classification belonging to Division; Ascomycota, Class; Sordariomycetes, Order; Xylariales, Family; Sporocadaceae. In Egypt *Pestalotiopsis* was isolated from soil the colonies was fast growing on potato dextrose agar attaining 8.5 cm in diameter after 7 days of incubation, Margin white changing to black towards the centre with the appearance of numerous acervuli. Conidia fusiform, straight or slightly curved, 5-celled, apical cell with mostly 2-4 simple appendages. Conidiomata acervular, appearing sporodochia like, black to dark black. Conidiophores hyaline, branched irregularly, septate, smooth (Figure 1, 2). *Pestalotiopsis* species occur on leaves and stems but have been occasionally reported from soil [8, 18]. Full studies on the conidial morphology of various isolates were made. *Pestalotiopsis* species demonstrated a marked variation in the configuration of conidia and number of setulae borne over the superior hyaline cell [19-20]. Microscopic identification of *Pestalotiopsis* species is relatively difficult, due to the variation in some characteristics such as conidial morphology, growth rate, and fruiting structure within species [21].

Tejesvi et al. [22], reported that the endophytic species of *Pestalotiopsis* dominant in the winter season and their colonization are comparatively low in the monsoon season. The colonization frequency of species of Pestalotiopsis increased with the increasing the age of the host plant and colonization frequency was variable [12].

Pestalotiopsis genus appears to be a universal organism present on tropical and semitropical plants. Also has been isolated as a saprophyte on bark and decaying plant material, and as an endophyte from the stems, leaves, flowers, and fruits of hundreds of tropical and subtropical rainforest plants [23-26]. *Pestalotiopsis* species are extremely distributed over the world, occurring on a wide range of substrata [12, 27]. Some *Pestalotiopsis* species are saprobes in soil [28], degraders of plant materials [29], or organisms growing on decaying wild fruits [30], while others are either plant pathogens [31] or reside as endophytes in plant leaves [32, 33]. Over 130 various compounds belong to different chemical classes have been isolated from *Pestalotiopsis*. Bioassays revealed that antifungal, antimicrobial, and antitumor activities are the most notable bioactivities of secondary metabolites isolated from genus *Pestalotiopsis* [34].

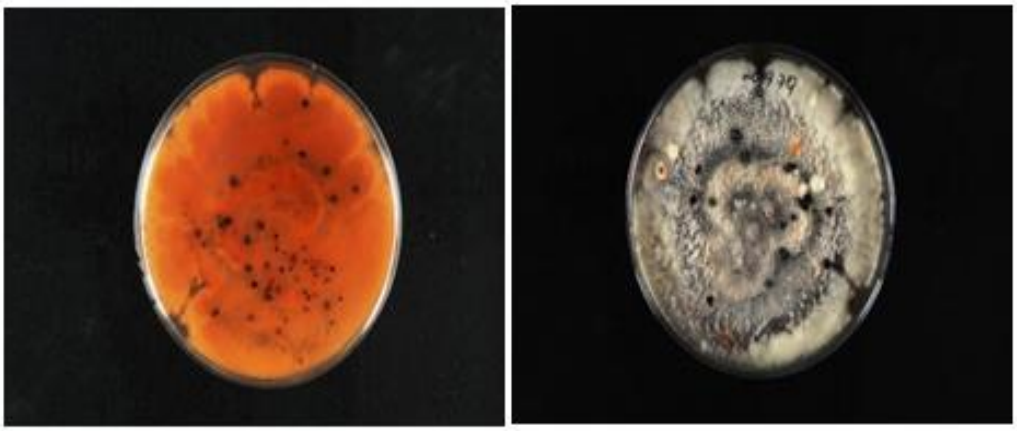

Figure (1). *Pestalotiopsis spp.* (Photographs was taken by Tangthirasunun Locality Thailand, hosted by *http://mycoportal.org*).

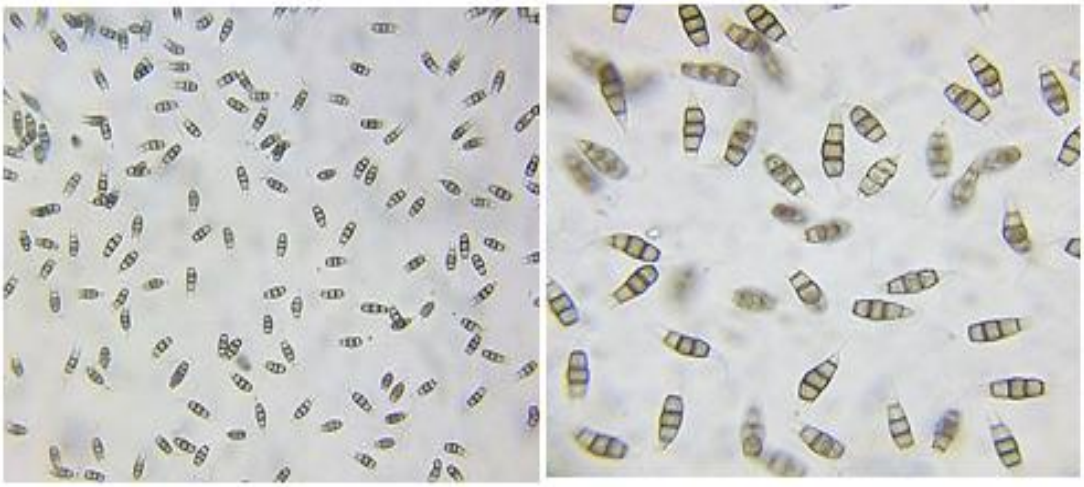

Figure (2). *Pestalotiopsis spp.* showing fusiform conidia with apical and basal appendages (Photographs was taken by Matthew Schink, Locality: United States, Florida, hosted by *http://mycoportal.org*).

Pestalotiopsis secondary metabolites

During recent years, *Pestalotiopsis* species have gained attention, due to the occurrence of numerous structurally unusual secondary metabolites. Some of them might be important as future drug leads for treatment of human diseases and control of plant diseases, since several antioxidants, immunosuppressants, anticancer agents, and others, have been identified from this genus [35, 36]. The aim of this review is to demonstrate secondary metabolites from species in *Pestalotiopsis* and highlight their reported bioactivities, and highlighting generosity and the unique chemical diversity of this fungal genus. Xu et al., [34] reported isolation of peptides, phenolic compounds, alkaloids, lactones, terpenoids, coumarins, isocoumarin derivatives, and chromones, quinones, semiquinones, xanthones, and xanthone derivatives from *Pestalotiopsis* species. Many studies have also described the variation in biologically active metabolites secreted by species of this genus [37, 38]. Yang et al., [39] have reported isolation of dihydroberkleasmin A, which is a novel eremophilane-type sesquiterpene from the culture broth of *Pestalotiopsis photiniae*. Also, they reported isolation of berkleasmin C, from the same culture broth. In another study, the endophyte *Pestalotiopsis photiniae* was the source of six novel photinides A–F which are benzofuranone-derived γ-lactones. The culture of *P. photiniae* was isolated from the plant *Roystonea regia*, collected from Jianfeng Mountain, China [40].

Liu et al., [41], reported isolation of pestaloficiols Q, and R (novel isoprenylated chromone derivatives), and pestaloficiol S (a novel benzofuran derivative), along with the three known metabolites, siccayne, anofinic acid, and pyrenophorol solid state cultures of *Pestalotiopsis fici*. The novel two metabolites, pestalotriols A and B, featuring a unique spiro [2.5] octane skeleton were also isolated from the endophytic fungus *Pestalotiopsis fici* (W106-1) which was isolated from the branches of the tea plant *Camellia sinensis* (Theaceae) in a suburb of Hangzhou, People's Republic of China [41].

Pestalotiopsol A was also isolated from *Pestalotiopsis* spp. together with 4-hydroxyphenylethanol [42]. *Pestalotiopsis* spp. produced abundant

compounds with diverse carbon skeletons such as polyketides, caprolactams, chlorinated pupukeanane, benzo [c]oxepin, isoprenylated chromone, benzofuranone-derived γ-lactones, highly functionalized spiroketal, cyclohexanone, ambuic acid, chlorinated benzophenone, cyclopropane, spiro azaphilone, chloropupukeananin, caryophyllene-type, humulane sesquiterpene, isobenzofuranone, and oxysporone [43-45]. Generally accepted that different fermentation conditions for microorganisms are likely to produce different types of secondary metabolites [46]. From many previous studies, *Pestalotiopsis* spp. produced many interesting bioactive secondary metabolites by using various solid and fermentation media.

Pestalotiopsis biological activities

Fungi of the genus *Pestalotiopsis*, as one class of the most widely distributed endophytic fungi, are common in their distribution, and many are saprobes, while others are either pathogenic or endophytic to living plants [47-49]. Since discovery of the anticancer agent taxol from an endophytic fungal strain of the genus *Pestalotiopsis* [35, 36], interest in searching for bioactive compounds from this fungal genus has increased significantly.

Moreover, these compounds from *Pestalotiopsis* spp. possessed many bioactivities: chloropupukeanolide A, pestalotheol and pestaloficiols, displayed an inhibitory effect on HIV-1; chloropestolide A, photinides, and pestalotiopsones F, showed significant cytotoxic effects; pestalofones , pestalachlorides, ambuic acid, pestalofones and isopestacin, displayed significant antifungal activities; ambuic acids and 6-hydroxypunctaporonins, displayed antimicrobial activity against gram-positive bacterium; pestalotines, significantly inhibited the radical growth of *Echinochloa crusgalli*. [50; 51], [33-45].

The plant endophytes, *Pestalotiopsis* spp., are creative manufacturers of bioactive secondary metabolites. Chemical studies on the fungus, *Pestalotiopsis* spp. have provided over 70 new natural products from different biosynthetic routes. Some of these metabolites have shown biological activities, including cytotoxic, antimicrobial and anti-HIV effects [52].

Nanotechnology for the production of nanoparticles using fungal cells is a recent phenomenon. Fungi are preferred for production of large amounts of nanoparticles over other alternative methods. Fungus like *Pestalotiopsis* sp. has been used for development of nanoparticles against pathogenic microbes [53]. Though, many papers have been published on the biological synthesis of nanoparticles, the potential of fungi is still much not explored [53].

Harmful sides of *Pestalotiopsis*

Species of this genus may cause diseases on a variety of plants and at times act in a severe manner which results in large plant yield losses [23, 54]. For example, *Pestalotiopsis* oenotherae was reported to induce leaf spot disease of evening primrose [50].

Five *Pestalotiopsis* species were isolated and identified according to the morphological characteristics of fungal colony (Colony color, Size and number of acervuli) and conidia (length, width, and color of median cells, length and the number of apical and basal appendages); they were *P. psidii*, *P. microspora*, *P. clavispora*, *P. neglecta* and *Pestalotiopsis* spp. All the isolates have pathogenic effect to guava fruits [55].

Isolation, purification, identification of pathogenic fungi that cause guava leaf spot was *Pestalotia psidii*. *Pestalotia* spp. took at the last years great attention, where it was isolated from many different plants, i.e. guava leaves and fruits [23], from pecan tree [56], from strawberry fruits [57-59] from olive trees and fruits and from many other plants.

Conclusion

Secondary metabolites from the endophytic fungi will be a cheap source for medical, agriculture and other industries. It is sure that the research on endophytic fungi will lead to isolate more novel compounds. This review demonstrate the chemistry and bioactivities of secondary metabolites from the fungal genus *Pestalotiopsis*. More than 130 compounds that have been reported from *Pestalotiopsis* spp. Bioassays revealed that antifungal, antimicrobial and antitumor activities are the most distinguished bioactivities of the secondary metabolites from *Pestalotiopsis*. *Pestalotiopsis* is unique endophytic fungus in producing large numbers of secondary metabolites having medicinal and pathogenic control effects.

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DOI: 10.31579/2693-7247/032