

Highlights on *Chaetomium* morphology, secondary metabolites and biological activities

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Abstract

Endophytic fungi always attract attention due to their generous production of bioactive and chemically novel compounds that have medical, agriculture, industrial applications. This review focused on *Chaetomium* as a model of endophytic fungi rich in therapeutic agents that have known medicinal and industrial application. Moreover, understanding the importance of this potent fungus encourage further studies to identify novel metabolites, and at the same time employing already known metabolites to evaluate their activity in order to be used in additional applications.

Keyword: *Chaetomium*; Secondary metabolites; Biological activities, applications

Introduction

The application of microbial secondary metabolites in general, and fungal metabolites in particular in various fields of biotechnology has attracted the interests of many researchers, thanks to the bioactive properties of these metabolites which made them employed in various applications in pharmaceutical, industrial, and agricultural fields. Fungal endophytes are microorganisms that live inside the interior tissues of living plants without bringing on any dangerous reactions [1-4]. Generally, endophytes are generous source of novel and biologically active natural compounds with incredible healing potentials. Recently, remarkable pharmacological agents have been generated from endophytic fungi [5, 6]. More than 50% of previously unknown biologically active substances have been isolated from endophytes [7]. Bio-pharmacological secondary metabolites originated from endophytes exhibit different antimicrobial, anticancer, antitumor, and anti-inflammatory activities [8]. The endophytic fungus, *Chaetomium*, is an excellent model that is used as a biotechnological tool in various fields. *Chaetomium* species are heterothallic fungi that found mainly in soil and organic compost and recently it was isolated from coral, soft coral, and marine algae, and *Chaetomium* are known for the production of secondary metabolites with vital biological activities. [9-14]. Different isolates of *Chaetomium* showed various mechanisms of antagonism against other pathogen fungi and they have been also reported to produce several antifungal metabolites [15, 16]. As an example *Chaetomium globosum* Kunze Fr., has been identified as potential biocontrol agent against a numerous plant pathogens [17].

In this review, highlights on the description, ecology, biological activities and secondary metabolites produced by *Chaetomium* Species were presented.

Chaetomium description and ecology

The word 'endophytes' describes microbes colonizing internal living tissues of plants without causing any immediate harmful impacts [1]. *Chaetomium* sp. is a dematiaceous filamentous fungus that can be isolated found air, soil, and also from plant debris [18, 19]. *Chaetomium* belongs to the class Pyrenomycetes (Ascomycotina), Order Sordariales and family Chaetomiaceae. There are about 95 species that have been identified under the genus *Chaetomium* worldwide [20]. As well as being a contaminant, *Chaetomium* sp. are also encountered as human pathogen. Some species are thermophilic and neurotropic in nature [21]. *Chaetomium* sp. are common fungal species with a worldwide ubiquitous distribution and are widespread in soil and on decaying plant materials but spore concentrations in outdoor air are not very high. Indoors, *Chaetomium* is found on wood, compost, sheet rock, straw, and similar cellulosic materials. It is also known as a soft-rot fungus for softwood and hardwood timber [22]. Colonies of *Chaetomium* are fast growing, colonies appear whitish cottony at the beginning, and turn grey to olive in color when become mature. From the reverse, color appear to be reddish tan or brownish black [23]. *Chaetomium* is ascomata globose, ellipsoid to ovate or obovate, ostiolate or non-ostiolate in a few species, with walls usually composed of textura intricata or epidermoidea in surface view, or of textura angularis in a few species. Ascomatal hairs hypha-like, flexuous, undulate, coiled to simply or dichotomously branched, with verrucose surface, or smooth in a few species (Figure 1, 2). Asci clavate or fusiform with 8 biseriolate or irregularly arranged ascospores, evanescent. Ascospores limoniform to globose, or irregular in a few species, bilaterally flattened, usually more than 7 μm in length. Asexual morphs, if present, acromonium-like. Member of the genus *Chaetomium*

are cosmopolitan and prevalent component of different ecosystem in a wide range of environments and climatic zone [24].



Figure 1. Chaetomium species with spiral setae and with oval ascospores. isolated and identified by Dr. Waill Elkhateeb (Photographs was taken by Dr. Waill A. Elkhateeb, Locality: National Research Center of Egypt).

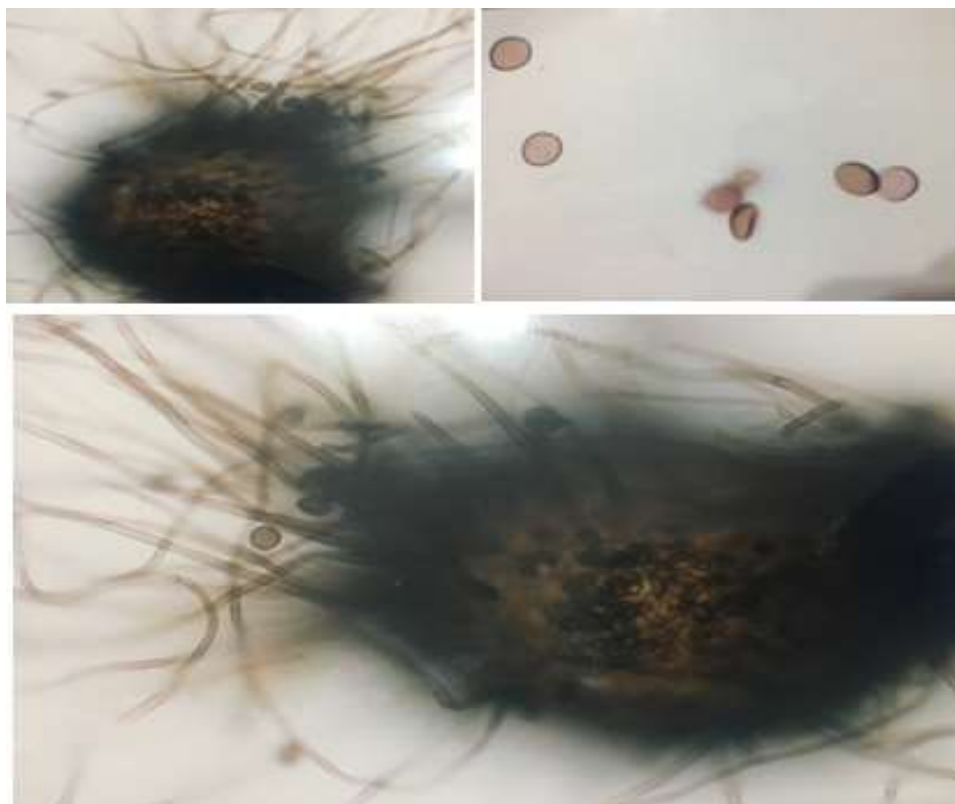


Figure 2. Chaetomium species with globosum ascospores isolated and identified by Dr. Waill Elkhateeb (Photographs was taken by Dr. Waill A. Elkhateeb, Locality: National Research Center of Egypt).

Chaetomium secondary metabolites

Over 200 secondary metabolites were isolated and identified from *Chaetomium globosum* including terpenoids, chaetoglobosins, tetramic acids, steroids, xanthenes, diketopiperazines, bis (3-indolyl)-benzoquinones, azaphilones, anthraquinones, pyranones, and orsellides. Some of these metabolites exhibit various bioactivities such as cytotoxic,

antimicrobial, antimalarial, anticancer, and antiviral activities.

Tawfik et al., [25] detected some compound which have investigate the anticancer and antimicrobial activity, The Metabolomics and bioassay-guided isolation afforded five pure compounds; p-hydroxybenzaldehyde, Uracil, 3-benzyl-6-isobutyl piperazine-2,5-dione, Cyclo (L-Alanin-L-leucin) and Cyclo-(L-proline-L-leucine) (Figure, 3).

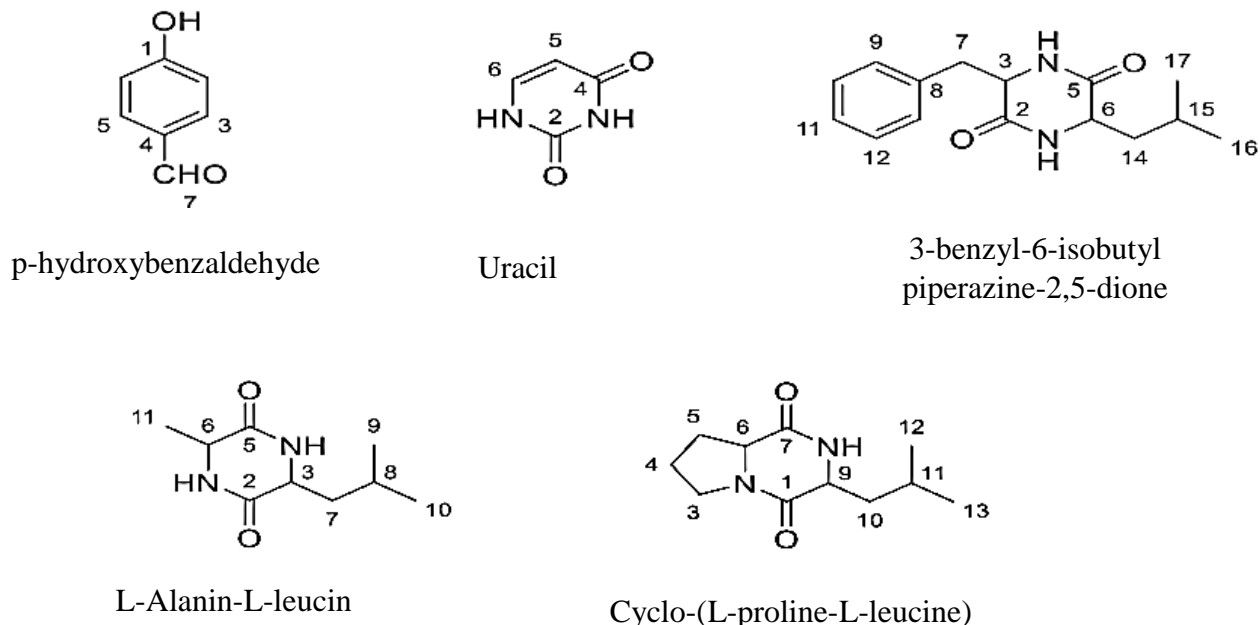


Figure 3. Some bioactive compounds produced by *Chaetomium* species.

Some biological activities of *Chaetomium* metabolites

Due to their generosity in production of secondary metabolites such as chaetoglobosins, xanthenes, anthraquinones, terpenoids, depsidones and steroids, researches were conducted to evaluate the biological activities of those compounds [26, 27].

Chaetomium species have potent antimicrobial activities that encouraged their use as biocontrol agents. Many reports have described different species potency, (especially *Chaetomium globosum*) against *Venturia inaequalis*, the apple scab pathogen [28]; also against *Macrophoma kuwatsukai*, *Rhizoctonia solani* and *Sclerotium rolfsii* (*Corticium rolfsii*) [29, 30]. Moreover, *Chaetomium* have promising antagonistic activities against the spot blotch pathogen, *Drechslera sorokiniana* [31, 32]. Furthermore, *Chaetomium* showed antifungal activities against *Fusarium*, *Pyricularia oryzae*, *Helminthosporium*, *Pyrenophora*, *Pythium ultimum*, *Sclerotinia sclerotiorum*; *Cochliobolus sativus*, *Alternaria raphani*, [33, 34]. Also, application of *C. globosum* as a biocontrol agent for controlling late blight disease in potato plants showed promising results and resulted in greater tuber yield. Similarly, it was reported that *C. globosum* could suppress the damping-off of sugar-beet caused by *Pythium ultimum* [35, 36]. On the other hand, *Chaetomium* species showed also good antibacterial activities against gram positive and negative bacteria especially *Escherichia coli* and *Staphylococcus aureus* [37].

The cytotoxicity and anticancer properties of *Chaetomium* species have also been described. For example, A new dihydroxanthone was isolated from *Chaetomium globosum* showed anticancer activity against a panel of seven human solid tumor cell lines (Wijeratne et al., 2006). The

polysaccharides obtained from *Chaetomium globosum* CGMCC 6882 showed anticancer activities against human lung Cancer A549 Cells [38]. Flavipin produced by *Chaetomium globosum* showed antiproliferative activity against A549, HT-29 and MCF-7 cancer cells in dose dependent manner with an IC50 concentration of 9.89 µg/ml, 18 µg/ml and 54 µg/ml, respectively [39]. Two novel compounds (methyl 9-dihydro-8-trihydroxy-9-oxo-Hxanthene-1-carboxylate as a member of xanthenes and (E)-methyl 2-hydroxy-6, 6-dimethyl hept-3-enoate) extracted from *Chaetomium globosum* isolated from Egyptian soil showed anti-proliferation activities against MCF-7 human breast cancer cell line and HEPG-2 human liver carcinoma cell line [40].

It should be noted that co culturing specific bacterial species were reported to induce metabolites production by *Chaetomium* [41-44]. *Chaetomium* species exerted also promising nematicidal activities especially against *Meloidogyne javanica*, *Heterodera glycines* and *Meloidogyne incognita* [45-50].

Conclusion

Emerging of antibiotic resistant microbes, as well as new diseases that threaten human life, besides the growing awareness of the dangerous impacts of using chemicals for pests and fungal control, are serious that require continuous search for potent sources of potent compounds from natural sources.

Recently, biocontrol of soil-borne pathogens has attracted attention as a promising support or alternative to currently used harmful chemicals. *Chaetomium* species in general, and *Chaetomium globosum* in particular, represent promising biocontrol agents that can get rid of pathogens and

increase yield. Understanding the nutritional needs, mode of action, and quantification of fungi in soils are important factors that require further studies.

Development and easiness of isolation, and molecular identification of *Chaetomium* have facilitate discovering new species. Also, progress in chemical methods of extractions and invention of advanced instruments for chemical identification of compounds have open the way for the discovery of novel compounds with potential biological activities.

Using molecular markers, in depth study of interaction between *Chaetomium* and other microorganisms as well as their host plants are topics that require additional researches. Further investigations on the results of co-culturing *Chaetomium* with different bacterial species and its impact on the resulting metabolites are of extreme importance. Finally, investigating the potential bioactivities.

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