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Highlights on Unique Orange Pore Cap Mushroom *Favolaschia* Sp. and Beech Orange Mushroom *Cyttaria* sp. and Their Biological Activities

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Review Article

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Abstract

Fungi exist everywhere around us. However, edible Mushrooms represent promising source for novel compounds with potential uses in different biotechnological fields. Many mushrooms were sources of novel compounds showing biological actions such as antimicrobial, anticancer, antiinflammatory activities. Likewise, mushrooms are macrofungi that exist everywhere around us. They have significant roles in human life as source of nutrition and bioactive compounds. Many mushrooms have been reported as promising biotechnological tools for production of secondary metabolites of various biological activities. *Favolaschia* sp.; *Cyttaria* sp. mushrooms are especially interesting due to the rareness of Basidiomycetes. In this review, the ecology, occurrence, of unique *Favolaschia* sp.; Cyttaria sp. mushrooms were described, and their biological activities.

Keywords: Medicinal Mushrooms; *Favolaschia* sp.; *Cyttaria* sp.; Biological Activities

Introduction

Mushroom producing fungi belong to Basidiomycetes and Ascomycetes, including edible and non-edible species, and some mushroom fruiting body produces basidiospores at the tip of club like structures called basidia, which are arranged along the gills of the mushroom [1-5]. Mushrooms have been documented for centuries as use as food and medicine as they are generous sources of nutrients and biologically active compounds that have various applications in agriculture, food, pharmaceuticals, cosmetics, and food related industries, amongst others [6-10].

Mushroom obtain their nutrition through being saprotrophs, parasites, or symbionts such as mycorrhiza. Mushrooms are the reproductive phase (fruiting bodies) but they there is also a vegetative phase to these fungi (mycelia). Edible mushrooms are often low in calories and can be healthy sources of proteins, flavonoids, metals, amino acids, minerals, volatile oils, carotenoids fats, phenolic compounds, and different vitamins and ergosterol that can be used as a source for vitamin D2 [3,5,11-18] .

The diversity of compounds extracted from mushrooms has attracted attention as a mine for novel compounds. Some compounds they contain have been classified as Host Defence Potentiators (HDP) which can have immune system enhancement properties [103, 105]. Various compounds are responsible for different therapeutic activities of many mushrooms genera. Various biological activities have been reported such as anticancer, antiinflammatory, hypoglycemic, antimicrobial, antioxidant, immunomodulatory, antiviral, hepatoprotective, antineurodegenerative, antiangiogenic, and hypocholesterolemic activities [19-28].

Favolaschia sp.

Favolaschia sp. belonging to Basidiomycota; Class: Agaricomycetes; Order: Agaricales; Family: *Mycenaceae. Favolaschia* sp., commonly known as the orange pore fungus, is a species of fungus in the family *Mycenaceae.* Due to its form it is also known as orange pore conch or orange Ping-Pong bat. Throughout much of its expanded range *Favolaschia calocera* is now considered an invasive species. It colonizes ruderal sites along transport routes and can become main in habitats disturbed by human activity. *Favolaschia calocera* is a wood-inhabiting saprotrophic fungus. It often has a bright yellow color at first, and can later appear in a brownish yellow color, though it often presents as a bright orange stalked fan, 5 mm–30 mm diameter, with prominent pores on the underside. Fruit-body: This little fungus is very bright orange in colour. It is fan shaped like a ping pong bat, with a short stem (up to 20 mm long), attached to the side of the cap and to logs or dead branches. Instead of gills it has large pores giving it a honeycombed appearance. The pore openings are polygonal to elliptical with a finely hairy inner surface. There are generally 1–2 pores per mm but they are smaller and shallower near the margin. The stem is rudimentary, about 5mm long, with sparse short white hairs and laterally attached [29-32]. The pores are visible through the thin flesh. Spore print: White. Habit: Although not common in gardens. It grows in large troops on logs and is very visible in the rainforest (Figures 1 and 2).

Figure 1: Favolaschia calocera**,** (Photo was taken by: Mikey Watson. Locality: New Zealand, Auckland, Rhinevale close Henderson Auckland (Cited in***: https://mycoportal.org).***

Figure 2: Favolaschia Sp, (Photo was taken by: John B. Locality: New Zealand, Nelson, 14 Rocklands Rd, Clifton (Cited in: https://mycoportal.org).

Favolaschia Sp. Biological Activities

Kornsakulkarn, et al. reported that fourteen new compounds, oudemansins, oudemansinols, favolasins, favolasinin, polyketides, and (R,E)-2,4-dimethyl-5-phenyl-4-pentene-2,3-diol, together with nine known compounds were isolated from the basidiomycete fungus *Favolaschia* sp. BCC 18686 [33]. Two new compounds, favolasin E and 9-oxostrobilurin E, were isolated from *Favolaschia calocera* BCC 36684 along with nine β-methoxyacrylate-type derivatives. Compounds in the class of oudemansins and strobilurins exhibited moderate to strong antimalarial

activity with relatively low cytotoxicity against Vero cells. Potent antimalarial activity was demonstrated for 9-methoxystrobilurins G, K, and E. Also, several compounds showed specific cytotoxicity against NCI-187 cells (human small-cell lung cancer).

Two strobilurins, 9-methoxystrobilurin B and 9-methoxystrobilurin G, two monochlorinated 2,3-dihydro-1-benzoxepin derivatives, and butenolide, together with four known compounds, strobilurin B, 9-methoxystrobilurin A, and oudemansins A and B, were isolated from culture BCC 18689 of the fungus *Favolaschia* sp. 9-Methoxystrobilurins A, B, and G and oudemansins A and B exhibited antimalarial, antifungal, and cytotoxic activities [34]. Wood, et al. Submerged liquid cultures of the basidiomycete *Favolaschia pustulosa* afforded the novel 9-methoxystrobilurin derivatives, 9-methoxystrobilurin L and 9-methoxystrobilurin E, and the related oudemansin derivative, oudemansin L [35]. 9-methoxystrobilurin L was cytotoxic to cells of the human B lymphoblastoid cell line (Jijoye), with an IC50 of 1.8 nM. This cytotoxicity was observed in a 5- day assay only and was not apparent after 2 days. 9-methoxystrobilurin L showed some antibacterial activity against *Bacillus subtilis* and antifungal activity against *Candida albicans*.

Favolaschia sp. 87129, *Pterula* sp. 82168, *Collybia nivalis* and Omphalotus olearius were cultivated on natural substrates. The antibiotic metabolites oudemansin A. strobilurins A, D, illudin S and pterulone were isolated and identified. A new antifungal metabolite, pterulone B, was described from cultures of *Pterula* sp. 82168 on wood. *Collybia nivalis* was found to be the first species of this genus to produce strobilurins and oudemansin A. The concentrations of the antibiotics, however, were sufficient to inhibit other saprophytic fungi [36]. Favolon triterpenoid from a *Favolaschia* Species exhibits potent antifungal activity but does not show cytotoxic activity on L 1210 cells [37]. Laschiatrion, a new antifungal antibiotic, was isolated from fermentations of *Favolaschia* sp. 87129. Laschiatrion exhibits broad in vitro activity against several human pathogens while no antibacterial and cytotoxic activities could be detected. The structure was elucidated by spectroscopic techniques [38].

Cyttaria Sp.

Cyttaria sp., commonly known as the myrtle orange or beech orange, is an orange-white coloured and edible ascomycete fungus native to Australia. It is a specific parasite of myrtle beech (*Nothofagus cunninghamii*) trees. *Cyttaria gunnii* is an ascomycete in Class: Leotiomycetes; Order: Cyttariales; Family Cyttariaceae. It is a caulicolous (stem parasite) fungi, restricted to species of *Nothofagus*, specifically *Nothofagus cunninghamii*, *Nothofagus fusca*, and *Nothofagus menziesii*. The species is distributed throughout Australia, New Zealand, and Tasmania wherever host trees are also found. The fruiting bodies, which grow in clusters, are usually around 2cm in diameter. The yellow/orange cup-shaped cavities form upon maturity to release wind-dispersed spores.

Stromata solitary or in dense clusters, up to 2 cm in diameter, pear-shaped, smooth and dry but becoming slimy if wetted, fawn or tan above, light coloured below, bright yellow when mature except for a sterile base which remains white. Hollow at maturity, internal fibres white. Apothecia very numerous, up to 200, bright yellow. Papillae small, scattered between apothecia, appearing as white flecks on young stroma, arising as minute elevations within shallow depressions, not raised above the surface of the stroma. Pycnidia absent. Asci 145-165 x 14 µm, ascospores sub-globose 12-12.5 x 6.5-12 µ, dark coloured, and spore print black. Paraphyses as long as asci, 2 µ wide, septate, branched, swollen at ends. Habitat: An obligate parasite forming globose galls on *Nothofagus menziesii* (Hook f.) Oerst, in New Zealand and *Nothofagus cunninghamii* (Hook. f.) Oerst, in Tasmania and Victoria. Range in New Zealand as for host (Figures 3&4) [39,40].

Figure 3: *Cyttaria gunnii*, (Photo was taken by: Kristof Zyskowski. Locality: Australia, Tasmania, Mount Field National Park, National Park, Tasmania, Australia (Cited in: https://mycoportal.org).

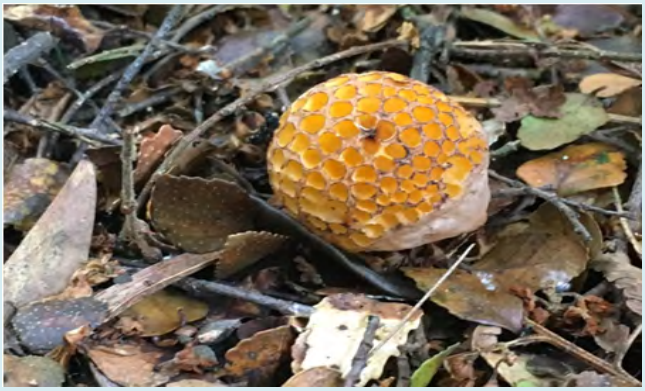

Figure 4: Cyttaria Sp. (Photo was taken by Tng, D. Locality: Australia, (Cited in: https://mycoportal.org).

Cyttaria sp. Biological Activities

The antioxidant capacities of the methanolic extracts of the dried caps of *Cyttaria gunnii* was determined using a number of different chemical reactions in evaluating multi-mechanistic antioxidant activities. These included the Trolox equivalent antioxidant capacity, ferric ion reducing antioxidant power, and ferrous ion chelating activity. Mineral contents of the dried caps of the mushroom was also determined by inductively coupled plasma–optical emission spectroscopy. The results indicated that *Cyttaria gunnii* edible wild mushrooms have a high antioxidant capacity. It can be concluded that *Cyttaria gunnii* edible wild mushroom are good source of nutritional antioxidants and a number of mineral elements [41].

Chemical and bioactive properties of nine wild edible mushrooms from native Nothofagus forest from Patagonia, Argentina. Macronutrients, sugars, fatty acids, tocopherols, organic acids, phenolic compounds and antioxidant properties were determined by Toledo, et al. [42]. Protein was found in high levels *Cyttaria hariotii*. All of them presented mannitol and trehalose as main sugars. The major fatty acid found was linoleic acid, followed by oleic acid and palmitic acid. All species presented oxalic and fumaric acids, while some also had malic, quinic and citric acids. Tocopherols composition was variable. All presented the best results in antioxidant activity assay, the highest content of phenolic compounds presenting gallic, p-hydroxybenzoic, p-coumaric and cinnamic acids.

The edible mushroom *Cyttaria espinosae* is a valuable food resource, not only because its pleasant taste, but also for its nutritional properties. Leiva-Portilla, et al. studied the physicochemical characterization and antioxidant capacity determination of dehydrated *Cyttaria espinosae* [43]. The results show that this wild mushroom is a good source of β-carotene, proteins and nutritionally relevant minerals, especially K and Fe. Also, dehydration of *Cyttaria espinosae* by freeze-drying gives the possibility of adding value to this mushroom, due to the bioactive compounds are maintained, the structure were less collapsed and fewer changes occurred with respect to color and appearance when comparing with hot air-dried samples. And finally show that drying technologies will help to expand the market for this valuable resource and poses the challenge of working for a better management and conservation of related habitats [43,44].

Conclusion

Mushrooms are generous sources of numerous secondary metabolites showing various biological activities of great importance in different field, especially in the field of pharmaceutical industries. This review represents chemical composition and nutritional value of most of *Favolaschia sp.* and *Cyttaria* sp. Furthermore, it provides important information necessary to characterize and define the use of these species as, functional foods and sources of bioactive compounds. Moreover, such rarely isolated mushrooms can represent unique sources for novel metabolites that may contribute in treatment of currently untreated diseases or have other promising applications that help in serving humanity.

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