A24: Seaweed-Derived Phenolic Compounds as Natural Antifungal Additives for Bio-Based Building Materials

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This abstract has undergone single blind review by the ICMB25 Conference Scientific Committee.

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About the conference
The following abstract is from the 3rd International Conference on Moisture in Buildings (https://ukcmb.org/icmb25) held in UM Guimarães, Portugal, on the 23-24 Oct 2025. All abstracts published here underwent single blind review by the Conference Scientific Committee.

Abstract

This study investigates the potential of seaweed-derived phenolic compounds to enhance mould resistance in bio-based building materials. Phenolic compounds extracted from brown seaweed were evaluated for their antifungal activity against *Aspergillus niger*. *In vitro* tests using the poisoned food technique showed an average inhibition rate of 53.3 % by day 4. When incorporated into a biocomposite, phenolic treatment resulted in 84 % inhibition of fungal colonisation over 8 days. While complete inhibition was not achieved, treated samples consistently exhibited less fungal growth compared to controls. These findings warrant further study into the long-term performance of seaweed-derived phenolic compounds and their antifungal efficacy against a wider range of indoor mould species.

Keywords: Seaweed-derived phenolic compounds, Antifungal agents, Bioactive additives for building materials

1. Introduction

Moisture retention in building materials creates ideal conditions for fungal colonisation [1], which poses risks to structural integrity, indoor air quality, and occupant health [2]. While current practice relies on metal-based agents (e.g., silver nanoparticles) or synthetic compounds (e.g., quaternary ammonium compounds) [3], these are typically non-biodegradable and environmentally toxic. Brown seaweed emerges as a promising bio-resource due to its high content of phenolic compounds — natural antioxidants with known antifungal properties. Although seaweed-derived phenolics have been studied in biomedical [4] and food packaging contexts [5–6],

their application within building materials has not been widely explored. This study investigates the antifungal potential of phenolic compounds extracted from brown seaweed, focusing on their inhibitory effects against *A. niger*, a common mould found in indoor buildings. The research aims to evaluate these compounds under two conditions: *in vitro* and embedded in a seaweed–clay biocomposite developed for a 3D-printable architectural wall system that passively buffers moisture. The broader objective is to assess the viability of using bio-based solution to develop antifungal building materials that support sustainable construction practices.

2. Methodology

2.1. In Vitro Antifungal Assay – Poisoned Food Technique

Phenolic compounds were extracted from 80 commercial *Ecklonia cava* capsules (each containing 100 mg of seaweed) using solid-liquid extraction with 70 % ethanol. Samples were agitated (125 rpm, 30 min), centrifuged (6000 rpm), and the solvent was evaporated overnight. The rehydrated supernatant was filtered (0.2 µm) and incorporated into Potato Dextrose Agar (PDA) at ~40 °C before solidification. Control plates (no extract) were prepared identically. Each condition was tested in triplicate (n = 3) and inoculated with 7 mm agar plugs of *A. niger*. Plates were incubated in the dark at 25 °C, and radial mycelial growth (mm) was measured once the mycelium in any sample reached the edge of the Petri dish. Mycelial inhibition was calculated using the formula: Inhibition (%) = (dc – dt) / dc × 100, where dc = control mycelial diameter, dt = treated sample mycelial diameter.

2.2. Antifungal Testing in Seaweed-Clay Biocomposite

Fresh brown seaweed was collected from Westgate-on-Sea (Kent, England) and processed using 200 mL of 40 % ethanol solid–liquid extraction method, as described in Section 2.1, with 50 g of dried seaweed powder. The biocomposite mixture containing 25 g clay, 7.5 g seaweed powder, 25 g grog, 3.5 g xanthan gum, and 0.5 g sodium alginate was split into two equal portions: one rehydrated with 50 mL of extract, the other with 50 mL of distilled water. ~25 g of the wet mix were placed into 55 mm Petri dishes (n = 3). Each sample was inoculated at three points with 10 µL of an *A. niger* spore suspension (1×10^6 spores/mL). The Petri dishes were then sealed and incubated at 25 °C in a dark chamber. Fungal growth was assessed on days 1, 4, and 8. Mould coverage was measured in Adobe Illustrator and Rhino 8. Inhibition (%) was determined as (Ac – At) / Ac × 100, where Ac and At are the mould-covered areas of the control and treated samples, respectively.

3. Results

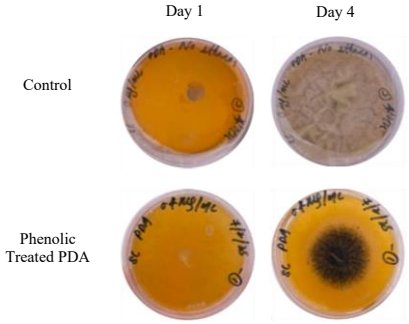

Figure 1. *A. niger* growth on PDA supplemented with *E. cava* phenolic extract using the poisoned food technique. Reduced mycelial growth observed on day 4 compared to the control.

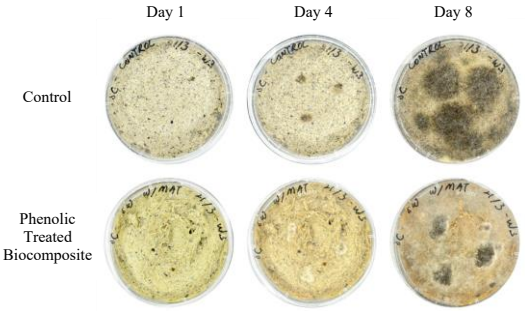

Figure 2. *A. niger* growth on biocomposites supplemented with fresh seaweed phenolic extract. Phenolic-treated samples showed less extensive mould colonisation compared to the control.

3.1. In Vitro Antifungal Assay – Poisoned Food Technique

By Day 4, control PDA plates showed full mycelial coverage by *A. niger*, whereas treated samples containing seaweed-derived phenolic compounds exhibited visible growth inhibition (Figure 1). Mycelial diameters in the

treated plates measured 26 mm, 26 mm, and 25 mm across replicates, yielding an average inhibition rate of 53.3 % relative to the control.

3.2. Antifungal Testing in Seaweed-Clay Biocomposite

By Day 8, untreated seaweed–clay biocomposites exhibited dense *A. niger* colonisation, while phenolic-treated samples showed visibly reduced growth (Figure 2). Mould coverage reached 8.26 cm^2 in control sample, compared to 1.31 cm^2 in treated biocomposite, representing an 84 % inhibition of mould colonisation.

4. Discussion and Conclusion

Seaweed-derived phenolic compounds demonstrated antifungal activity against *A. niger* in both *in vitro* assay and within seaweed-clay biocomposites. Partial inhibition was likely due to sub-inhibitory phenolic concentrations, highlighting the potential to incorporate antifungal phenolics into bio-based building materials. However, as the experiments were limited to a single mould species and short-term exposure, further investigations are necessary to evaluate the efficacy of these compounds against a broader range of indoor mould species and to assess their long-term performance under conditions representative of occupied indoor environments.

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