Development of Filaments Using Cell Wall Material of Filamentous Fungi Grown on Bread Waste for Application in Medical Textiles

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Abstract

There is a need for new sustainable textiles to reduce the problems related to the production of current textiles, including the use of nonrenewable resources, shortages of cotton, and the use of harmful chemicals. Bio-based materials developed from natural biopolymers are attracting increasing interest as sustainable alternatives to fossil-based materials. The cultivation of filamentous fungi results in fungal biomass that is rich in biopolymers. In fungal biorefineries, food waste can be valorized via fungal cultivation, resulting in a broad range of value-added products.

In this study, filaments were designed from the cell wall material of filamentous fungi grown on bread waste and evaluated for application in medical textiles. The developed route for filament production uses benign processes and reuses food waste. The fungal cell wall, isolated from fungal biomass (mycelia), consists of a matrix of biopolymers, including chitin, chitosan, and glucan. The aim was to directly utilize the cell wall material for developing filaments without needing extensive purification of these biopolymers.

Fungal biomass was obtained by cultivating an edible filamentous fungus (*Rhizopus delemar*) with a cell wall rich in chitosan and chitin. Submerged cultivation using bread waste as a substrate was demonstrated on multiple scales, from 0.2 L shake flasks to a 1.3 m^3 bioreactor. First, a protein hydrolysate was recovered from the fungal biomass via mild enzymatic treatment. The protein hydrolysate exhibited potential as an emulsifier and foaming agent. The never-dried cell wall material was isolated using alkali treatment for filament production. Hydrogels formed from the cell wall material after the addition of lactic acid. Hydrogel formation was attributed to the protonation of the amino groups of chitosan present in the cell wall. The hydrogels were wet spun into monofilaments using ethanol as the coagulation agent. The fungal monofilaments are suggested as suitable candidates for applications in medical textiles owing to their biocompatibility with human fibroblast cells and their antibacterial and wound-healing properties. This method was also applied to another strain of edible filamentous fungi (*Aspergillus oryzae*), wherein the cell wall mainly comprises chitin and glucan. The cell wall material obtained from *A. oryzae* was subjected to deacetylation and freeze–thaw pre-treatments to achieve gelation, and the formed hydrogels were successfully wet spun into monofilaments.

The work presented in this thesis introduces the potential of the valorization of bread waste into value-added products based on a biorefinery concept utilizing different edible fungal strains. This process focuses on scalability and environmental benignity. This study contributes to the development of novel biomaterials and fungal proteins obtained from fungal cell walls for application in medical textiles and food products, respectively.

Keywords: Antibacterial; *Ascomycetes*; biocompatibility; chitin; chitosan; chitin–glucan; deacetylation; filamentous fungi; food waste; fungal textile; hydrogel; medical textile; monofilament; *Mucoromycetes*; submerged cultivation; wet spinning; wound healing