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Exploitation of Model Microbial Communities and Food Wastes for the Production of Microbial Biocellulose

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Abstract

The production of microbial biopolymers has receiving great attention because of their eco-friendly and sustainable nature compared to petroleum-based and chemically synthesized materials (Fatima, 2024). Bacterial cellulose (BC) is certainly one the most promising and attractive biopolymer, and its chemical and structural properties (e.g. e.g., chemical purity and stability, nanoscale fibrous structure, high water-holding capacity, hydrophilicity, high polymerization and crystallinity index, moldability), make it suitable for several applications in food- and biomedical-related fields (e.g. coating, emulsifying and gelling agents, active packaging, prebiotics, drug carriers, material for implantable devices and tissue repair; (Venturelli et al., 2025). The global BC market is expected to rise in the coming years, and the government regulations on the reduction of carbon emissions and plastics usage, as well as the progress in BC production processes (e.g. microbial strains, cultivation media, biopolymer biochemistry), will certainly drive the evolution of BC market. Furthermore, the use of agri-food wastes as low-cost substrates to produce microbial biopolymers may be a promising circular-economy strategy for waste valorisation, while reducing the production and downstream recovery costs. In this study, we used the “kombucha SCOBY” concept (i.e., interaction of Symbiotic Culture of Bacteria and Yeasts in a complex cellulose-based biofilm), to design and assembly Model Microbial Communities (MMC), consisting of several acetic acid bacteria (AAB; core strains), lactic acid bacteria (LAB; helpers) and yeast (Y; helper) strains, able to boost BC production in different substrates (including agri-food wastes). Fruit and vegetable wastes (FVW) (i.e. potato, carrots, pear and apple peels) were used for the formulation of low-cost substrates for production of BC. The BC produced by using apple or pear extracts (the best substrates) was subjected to rheological and mechanical analyses (e.g., elasticity, fracturing capability) to verify the structural properties and BC potential applications. The results showed that the assembled communities boosted the BC yield compared to the single AAB strains, avoiding the constraints related to the use of axenic cultures and highlighted the potential of MMC for the production of microbial polymers. Pear and apple wastes boosted the BC yield compared to conventional synthetic growth medium, probably due to the high content of sugars fermentable by AAB. The type and % of wastes, however, affected the BC properties, suggesting that waste selection should be based not only on BC yield, but also on rheological data (which may not always consistent). Further trials are ongoing to exploit BC potential as biofilm. Our study demonstrated that the microbial

biotechnologies may offer scientifically sound strategies to support zero-waste principles, sustainability, and resilience of the agri-food system, ensuring renewable materials (e.g., biopolymers/bioplastics) and contributing to waste reduction and valorisation (e.g., use as alternative and low-cost substrates; recovery of food matrices through fermentative processes).

Keywords: biocellulose, food wastes, microbial communities, sustainability

References

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