Biosurfactants Produced by Yeasts: Environmental Roles and Biotechnological Applications

Subjects: Mycology
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Biosurfactants are amphipathic compounds produced by various microorganisms, including fungi and yeasts, with those produced by the latter being of particular interest as they are considered microorganisms of low or no sanitary risk. This article presents an analysis of the available information regarding the role these compounds play within the ecological habitat where yeasts inhabit, as well as their potential biotechnological applications in commercial areas. Some of the biological roles that biosurfactants play for their producing microorganisms are unknown and can be highly diverse, depending on the adaptive needs microorganisms have to survive the environmental conditions prevalent in their habitat. However, some of these roles that have been reported are related to nutrient availability, cellular communication, and competition, as well as surface colonization. The structures of biosurfactant molecules produced by yeasts are highly diverse, and so far, have been reported as sophorolipids, carbohydrate–protein–lipid complexes, carbohydrate–protein polymers, mixtures of lactones, and mannosylerythritol lipids. In addition to their properties as surfactants and/or emulsifiers, many of these molecules have also been reported to possess biological activities, including antimicrobial, antifungal, antitumoral, antioxidant, antiadhesive, antiviral, ultraviolet (UV)-protectant, anti-aging agent, moisturizing, and enzyme-activator/inhibitor properties. By understanding the functions that biosurfactants perform in nature, novel and efficient methods for their production can be proposed, as well as new applications in areas such as pharmaceuticals, food, and cosmetics. The latter is of particular interest due to the growing biosurfactant market and the processes that demand greater knowledge about their production, biological, and environmental interactions for their management and disposal.

biosurfactants yeast natural role biotechnology

Yeasts are microorganisms widely distributed on the planet, capable of growing in different types of terrestrial and aquatic environments, in symbiosis with plants and animals, and in food products [1]. It has also been reported that some species are capable of populating environments with extreme conditions, such as pH, temperature, water activity, and nutrient limitation, among others. The survival of yeasts in this variety of environments has been related to abiotic and biotic factors; among the latter, their ability to adapt stands out, thanks to the production of compounds such as antioxidants, exopolysaccharides, antibiotics, and biosurfactants [2].

Biosurfactants are produced by diverse types of microorganisms and are characterized as amphipathic molecules with interfacial activity, capable of reducing the interfacial and surface tension of liquids. Biosurfactants have been

characterized by superior properties compared to synthetic surfactants, including their stability at high salinity, temperature, and pH values; the formation of stable emulsions, low toxicity, and improved biodegradability [3]. Biosurfactants produced by yeasts are more valued than those produced by bacteria due to their GRAS (Generally Recognized As Safe) status, especially when their production is required for applications in areas such as pharmaceuticals, cosmetics, or food. Some of the yeast genera reported as biosurfactant producers are *Candida*, *Yarrowia*, *Torulopsis*, *Pseudozyma*, *Kurtzmanomyces*, *Debaryomyces*, *Saccharomyces*, *Kluyveromyces*, *Rhodotorula*, *Wickerhamomyces*, *Galactomyces*, *Geotrichum*, *Apiotrichum*, *Pichia*, *Rhynchosporium* [1][4][5][6][7].

Bioprospecting has been a pivotal tool in the discovery of biosurfactants with remarkable properties, such as stability under extreme conditions or their production utilizing renewable feedstocks like agro-industrial and food industry waste [3][8]. The identification of their metabolites has contributed to the understanding of the roles these compounds play for the yeast that produced them in their ecological context. This information facilitates the identification of factors that promote the production of those metabolites under controlled laboratory conditions, as well as their mechanisms of action in diverse applications. Still, despite their significance, the biological roles of biosurfactants in the yeasts that produce them and in their native environments remain largely underexplored, often being limited to a few roles already characterized for other microorganisms. It is not easy to generalize the role biosurfactants play on the survival of yeast in their natural environment, given their diverse chemical nature [9].

On the other hand, the application of yeast biosurfactants is intrinsically linked to their molecular structure, which in turn is dependent on the yeast's origin. For instance, many biosurfactants exhibiting outstanding properties regarding resistance to extreme conditions and product stability have been reported to originate from yeasts isolated from extreme environments, both terrestrial and marine.

This chapter describes some of the strategies used in bioprospecting the yeast biosurfactants that were applied to diverse ecosystems, from Antarctic soil to marine sediments. Also, the biological roles of the yeast biosurfactants were analyzed in the context of the ecological habitats from which they were isolated. Moreover, the available information about their discovered biotechnological applications and considerations for their production has been reviewed.

References

1. Konishi, M.; Maruoka, N.; Furuta, Y.; Morita, T.; Fukuoka, T.; Imura, T.; Kitamoto, D. Biosurfactant-producing yeasts widely inhabit various vegetables and fruits. Biosci. Biotechnol. Biochem. 2014, 78, 516–523.
2. Deak, T. Environmental factors influencing yeasts. In Biodiversity and Ecophysiology of Yeasts; Springer: Berlin/Heidelberg, Germany, 2006; pp. 155–174.
3. Rawat, G.; Dhasmana, A.; Kumar, V. Biosurfactants: The next generation biomolecules for diverse applications. Environ. Sustain. 2020, 3, 353–369.

4. Amaral, P.F.; Coelho, M.A.Z.; Marrucho, I.M.; Coutinho, J.A. Biosurfactants from yeasts: Characteristics, production and application. In Biosurfactants; Springer: New York, NY, USA, 2010; pp. 236–249.
5. Souza, K.S.T.; Gudiña, E.J.; Azevedo, Z.; de Freitas, V.; Schwan, R.F.; Rodrigues, L.R.; Teixeira, J.A. New glycolipid biosurfactants produced by the yeast strain Wickerhamomyces anomalus CCMA 0358. Colloids Surf. B Biointerfaces 2017, 154, 373–382.
6. Eldin, A.M.; Kamel, Z.; Hossam, N. Isolation and genetic identification of yeast producing biosurfactants, evaluated by different screening methods. Microchem. J. 2019, 146, 309–314.
7. Sakaki, T.; Zähringer, U.; Warnecke, D.C.; Fahl, A.; Knogge, W.; Heinz, E. Sterol glycosides and cerebrosides accumulate in Pichia pastoris, Rhynchosporium secalis and other fungi under normal conditions or under heat shock and ethanol stress. Yeast 2001, 18, 679–695.
8. Campos-Takaki, G.M.; Sarubbo, L.A.; Albuquerque, C.D.C. Environmentally friendly biosurfactants produced by yeasts. In Biosurfactants; Springer: New York, NY, USA, 2010; pp. 250–260.
9. Ramdass, A.C.; Rampersad, S.N. Detection and diversity of the mannosylerythritol lipid (MEL) gene cluster and lipase A and B genes of Moesziomyces antarcticus isolated from terrestrial sites chronically contaminated with crude oil in Trinidad. BMC Microbiol. 2022, 22, 43.