Chapter 11
Microalgal Biorefinery: A Way Towards Sustainability and Circular Economy.

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ABSTRACT

This chapter investigates the potential of microalgae biorefineries as a sustainable approach to tackling global food security issues while fostering a circular economy. Microalgae, which are already being used to produce renewable energy sources like biodiesel, bioethanol, biohydrogen, and biogas, also offer a promising low-cost food source due to their rapid growth rates. The chapter addresses the challenges faced by the global microalgal market and examines the role of microalgae in achieving the United Nations Sustainable Development Goals (SDGs). The chapter indicate that microalgae play a significant role in both directly and indirectly supporting these SDGs. Additionally, microalgae contribute to the development of green communities by minimizing pollution, conserving natural resources, and promoting a sustainable environment. This chapter emphasizes the crucial role of algorefinery in advancing global sustainability initiatives and underscores their importance in enhancing the circular economy - Industrial Symbiosis.

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1. MICROALGAE GLOBAL MARKET

Microalgae cells, some of the earliest life forms on our planet, have undergone billions of years of evolution, leading to a remarkable complexity and diversity that enables a variety of applications. These microorganisms are photosynthetic and autotrophic, existing as either unicellular or multicellular forms, and they thrive in both freshwater and saltwater environments. Their sizes range from just a few micrometers to several hundred micrometers, and they are composed of lipids, proteins, carbohydrates, and other compounds. Generally, the chemical formula for microalgae is CO0.48H1.83N0.11P0.01, with key components including lipids (7–23%), carbohydrates (5–23%), and proteins (6–52%) (Borowitzka, 2013). The exact chemical composition of microalgae varies significantly depending on the species and the conditions in which they are grown. These tiny organisms can be found in a wide array of environments and are relatively cost-effective to cultivate. There are approximately 80,000 species of microalgae, with around half being extensively researched for commercial uses. Microalgae are primarily divided into three main groups: rhodophytes (red algae), chlorophytes (green algae), and cyanobacteria (green-blue algae), which also encompass diatoms (Oliveira et al., 2022).

Microalgae have been beneficial to humans since ancient times, primarily as a source of nutrition. Although the significance of microalgae in biological processes has been recognized for centuries, systematic cultivation of microalgae began only in the 1950s (Burlew, 1953). The field of microalgal biotechnology is a relatively new area of research that has seen rapid growth, paralleling the swift development of supply units and products derived from microalgae. This field encompasses both eukaryotic microalgae and prokaryotic cyanobacteria. Since 2005, there has been a notable increase in publications and research activities related to microalgae (Garrido-Cardenas et al., 2018). This trend aligns with the rising market value of microalgae-derived products and the expansion of production facilities (Forján et al., 2015). The global microalgae market was valued at around USD 3.4 billion in 2020, during the pandemic, and is projected to grow at a compound annual growth rate (CAGR) of 4.3%, reaching USD 4.6 billion by 2027 (Ahmad et al., 2023). This growth is largely due to the increasing recognition of microalgae as a sustainable source of food and energy.

Microalgae biofuels have the potential to challenge and possibly replace the fossil fuel industry, which is valued at $2.1 trillion, explaining the heightened interest from various industries (Curtin et al., 2019). Additionally, microalgae are being explored as a potential source of biofertilizers, biochemicals, and biochar for wastewater treatment (Khoo et al., 2021). Given their versatility across numerous fields and industries, microalgae represent a crucial resource.

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