CHAPTER 9

# Microalgal Cell Disruption and Lipid Extraction Techniques for Potential Biofuel Production

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## INTRODUCTION

The global energy crisis is mounting day by day due to the exponentially growing population and extensive industrial development. The conventional fossil fuels such as petrol, diesel, coal, and natural gas are considered as the basic sources to meet this energy demand [1]. However, the progressive depletion of these petroleum-based fuels is recognized as a future challenge. In this context, the concern regarding alternative sources of energy to replace the fossil fuels is increasing tremendously [1,2]. The increasing demand for bioenergy sources and bioactive compounds has intensified research into biofuels as a viable renewable source to fulfill these needs. The biofuels (e.g., biochar, biogas, biohydrogen, biodiesel, bioethanol, etc.) produced from biomass (e.g., wood and wood residues, plants, animal matters, waste energy feedstocks, algae or algae-derived biomass, etc.) have been considered as sustainable renewable sources to meet the future energy demand [3,4]. Among them, biodiesel is regarded as a promising alternative to the petroleum-based fuels for the transportation sector. Recently, microalgae-derived biodiesel has gained widespread interest as one of the promising substitutes to the nonrenewable fossil fuels.

Microalgae and macroalgae are a diverse cluster of aquatic organisms, usually found in the freshwater and the marine environments, which possess the ability to fix 1.83 kg of carbon dioxide ($CO_2$) while producing 1 kg of algal biomass [5]. Apart from that, microalgae also produce a wide range of valuable nutrients useful in various industries, such as proteins and carbohydrates, along with the lipids used to produce biofuels [6]. The microalgal lipid yield was estimated to be 20,000−80,000 L/acre/year, which is about 30 times more than that obtained from seed crops fuels [7]. In addition, microalgae are considered as effective source of biodiesel due to the rapid growth rate; ability to grow in various complex environments including wastewaters; high biomass productivity; low land use; nontoxic; biodegradable; less harmful gas emissions [8]; diverse biochemical composition [9]; limited competition with the edible crops; etc. [3]. There are several steps and techniques for processing of microalgae to different valuable products (Fig. 9.1). However, large quantities of chemicals or high energy inputs are required for the extraction of intracellular compounds from the cell compartment due to the recalcitrance, complexity, and diversity of microalgal cell walls [10]. Consequently, the use of microalgae as a feedstock for biofuel production is hindered by the process economics and sustainability [2]. For instance, about 25%−75% of the algal biomass comprises stored lipids; however, extraction of lipids is the most challenging and energy-intensive procedure due to the tiny algal cells, rigid cell walls, and limited contact between the solvents during lipid extraction [3].

Generally, the cell walls of microalgae are structurally robust, complex, and chemically diverse, and therefore, the disruption of the microalgal cell wall is the most crucial step to extract different valuable biomolecules (Fig. 9.2) from the cells. Moreover, the lipid extraction process is often influenced by the water content of biomass, selection of suitable solvents, the blocking effects from insoluble biomass residues, the limited lipid accessibility, the formation of stable emulsions, etc. Therefore, several alternative approaches (e.g., use of green solvents, direct transesterification, pretreatment for disrupting microalgal cells, etc.) for lipid extraction have been proposed to mitigate the

Microalgae Cultivation for Biofuels Production. https://doi.org/10.1016/B978-0-12-817536-1.00009-6