Chapter 1
Energy from Microalgae: A Brief Introduction

Eduardo Jacob-Lopes, Leila Queiroz Zepka and Maria Isabel Queiroz

Abstract This chapter provides a brief overview of some of the major steps in the development of microalgae-based processes for renewable energy production. The chapter attempts to highlight the development and evolution of the key concepts and research in the field, preparing the reader for the following chapters, which will deepen the discussion on the subject.

Keywords Algae · Microalgae-based process · Algae products Bioenergy · Biofuel

The race for renewables is underway. The growing trend toward the search for alternative and economically viable matrices is one of the main focuses of industrial biotechnology. Issues such as the global concerns of fossil fuels depletion, climate change, and increasing world population have become key determinants of the current energy imbalance (Staples et al. 2017).

Biofuels are considered the most likely sources of energy that can replace a sizeable amount of fossil fuels. Currently, biofuels are classified from first to fourth generation. The third generation biofuel production is mainly based on microalgae (Harun et al. 2010). Some microalgae are known to produce fairly high amounts of intra- and extracellular energy compounds that can be used for biofuels manufacture

E. Jacob-Lopes (✉) · L. Q. Zepka
Department of Food Science and Technology, Federal University of Santa Maria (UFSM), 97105-900 Santa Maria, RS, Brazil
e-mail: jacoblopes@pq.cnpq.br

L. Q. Zepka
e-mail: lqz@pq.cnpq.br

M. I. Queiroz
School of Chemistry and Food, Federal University of Rio Grande (FURG), 96201-900 Rio Grande, RS, Brazil
e-mail: queirozmariaisabel@gmail.com

E. Jacob-Lopes et al. (eds.), *Energy from Microalgae*, Green Energy and Technology, https://doi.org/10.1007/978-3-319-69093-3_1

(Singh et al. 2017). These organisms exhibit high photosynthetic efficiencies and yields up to twice that of terrestrial plants, and remain an attractive target for improving the sustainability of future bioenergy production (Chisti 2013).

Microalgae are a class of microorganisms that exhibit tremendously large biological diversity and metabolic plasticity (Cho et al. 2017). This terminology envelops a variety of prokaryotic and eukaryotic organisms. Some species can grow autotrophically and produce organic molecules while others are heterotrophic in nature, growing in the dark on complex organic material for energy and carbon source (Chew et al. 2017).

It is a consensus that the supply of sufficient energy qualities, with a minimum environmental impact, is among the main challengers of the energy world (Maroneze et al. 2016). However, the search for fossil energy substitutes that meet the requirements of energy sustainability in order to develop biofuels is not so recent. Microalgae are very promising candidates that can fill our energy hunger in a sustainable and environment-friendly manner. Two centuries ago, Rudolf Diesel, the inventor of the diesel engine, fueled the idea of the production of diesel from vegetable oil. This was the basis for using microalgae to generate energy (Barathiraja et al. 2017). Besides the energy concerns, the advantages in terms of environmental impact and sustainability have been considered. On the other hand, they also have the advantage of the parallel production of co-products and have the potential for the mitigation of pollutants, enabling the establishment of biorefineries in industrial integrated processes (Moreno-Garcia et al. 2017).

Regardless of the many possibilities of exploitation of energy from microalgae, today, one of the main interests in developing microalgae-based processes is because of the ability of these microorganisms to produce and accumulate lipids in their cells (Pereira et al. 2016). Microalgae oil consists of the neutral lipid triacylglycerol, which includes saturated and unsaturated fatty acids, which are stored in cytosolic and\or plastidic lipid bodies. The accumulation of such lipid bodies can be enhanced by abiotic stress, through to the adaptions of their biochemical metabolic pathways and cellular composition in response to external conditions including physiological inputs (Savchenko et al. 2017). In this sense, the possibility of lipids accumulation through the manipulation of environment culture conditions has a great potential for energy production. Biofuels from microalgae are no longer focused solely on achieving a high lipid yield and its conversion into biodiesel. Recent technology developments have been facilitated for the use of all algal metabolites. In addition, biodiesel, biohydrogen, bioethanol, bioethanol and, more recently, volatile organic compounds have been the main targets of the current exploitation of energy from microalgae (Santos et al. 2016; Zhu et al. 2017).

Independent of these potentialities, the single biggest and most critical barrier to the market deployment of commercially viable algae-based production remains the high cost of cultivating and harvesting the biomass feedstocks, currently a factor of 10–20, which is too high for commodity fuel production (Laurens et al. 2017).

Furthermore, in light of persisting low fossil fuel prices, the microalgae-based industry is forced to shift its focus from lower-value commodity biofuels and

bioenergy products to higher-value (non-energy) products that can be profitable today. In this way, at least until oil prices return to near their pre-2014 levels, or carbon emissions reductions are rewarded through higher carbon pricing in a global climate disruption mitigation policy, primary strategies for bioenergy production from microalgae will need to rely on a multi-product biorefinery approach. As such, a biorefinery approach that generates multiple high-value products from microalgae will be essential to fully valorize biomass and enable the economically viable co-production of bioenergy. Industrial operations that were leading the commercial development of algae-based biofuels have been increasingly redirecting their commercial focus toward the production of higher-value food, feed, and specialty products (IEA 2017).

In fact, there are significant barriers currently impeding the commercialization and economic production of microalgae for fuel markets, in particular in supporting the resource demands for large-scale deployment. The barriers range from incomplete knowledge of microalgae biology to the challenges associated with the scale-up of the processes (Wijffels and Barbosa 2010).

Therefore, to accelerate the production of energy from microalgae, besides the robust increase of the productivities, the minimizing energy, water, nutrients, and land-use footprints need to be a primary objective of productions systems and future research and development (Pantel et al. 2017). The chapters presented in this book are intended to help provide a deeper understanding and insight into the promises and challenges for microalgal biofuels and bioenergy technologies to be substantial contributors to future fuel supplies.

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