New BIOTECHNOLOGY 61 (2021) 99–107

Contents lists available at ScienceDirect

New BIOTECHNOLOGY

journal homepage: www.elsevier.com/locate/nbt

Full length Article

The role of microalgae in the bioeconomy

F. Gabriel Acién Fernández [a,*], Alberto Reis [b], René H. Wijffels [c,d], Maria Barbosa [c], Vitor Verdelho [e], Bernardo Llamas [f]

[a] Department of Chemical Engineering, University of Almería, Almería, Spain
[b] National Laboratory of Energy and Geology - LNEG, I.P, Lisbon, Portugal
[c] Bioprocess Engineering, AlgaePARC, Wageningen University & Research, Wageningen, the Netherlands
[d] Faculty of Biosciences and Aquaculture, Nord University, Bodø, Norway
[e] A4F Alga 4 Future S.A., Estrada do Paço do Lumiar Campus do Lumiar, Ed. E – R/C 1649-038, Lisbon, Portugal
[f] Polytechnic University of Madrid. ETSI Mines and Energy. Alenza 4, 28003, Madrid, Spain

ARTICLE INFO

Keywords:
Bioeconomy
Microalgae
Photobioreactor
Food
Feed
Cosmetics
Biomaterials
Biostimulants
Wastewater treatment
Bioenergy

ABSTRACT

The bioeconomy is a new and essential paradigm for reducing our dependence on natural resources and responding to the environmental threats that the Earth is currently facing. In this regard, microalgae offer almost unlimited possibilities for developing a modern bioeconomy given their metabolic flexibility and high biomass output rates, even when produced under harsh conditions, such as when treating wastewaters or using flue gases. In this article, the microalgal contribution to important economic activities such as the production of food and feed, cosmetics and health-related compounds is reviewed. Moreover, potential contributions of microalgae to emerging sectors are discussed, as in the production of biomaterials, agriculture-related products, biofuels and provision of services such as wastewater treatment and the clean-up of industrial gases. The different microalgal production technologies have also been analyzed to identify the main bottlenecks affecting microalgal use in different applications. Finally, the major challenges facing microalgal biotechnology in enlarging its contribution to the bioeconomy are evaluated, and future trends discussed.

Introduction

Microalgae contribute to the planet's sustainability, mainly by transforming CO_2 into O_2. They are the primary producers of biomass for aquatic systems, thus supporting life on Earth. Moreover, microalgal biotechnology is currently contributing to the global bioeconomy, producing valuable biomass for human-related applications such as pharmaceuticals, cosmetics, food and feed [1–3]. Nevertheless, microalgae can potentially contribute much more to the bioeconomy by increasing the current production capacity and developing new applications. They have been proposed as a source for biofuel, chemical and biofertilizer production, although they can also provide services such as wastewater treatment and clean-up of flue gases [4–6].

The term microalgae include both microalgae and cyanobacteria. Although they are different microorganisms (eukaryotic and prokaryotic, respectively), both perform oxygenic photosynthesis in the same way and are produced using the same fundamentals and technologies. Microalgae are produced in water and require adequately designed production systems. The design of these systems must be based on prior knowledge while also accommodating the requirements of target markets in terms of production capacity and quality among others. Microalgae are flexible microorganisms that can be cultivated under different conditions; indeed, they are produced in a wide variety of locations around the world [7]. Moreover, they can be cultivated without using valuable resources that are needed for other human-related applications, such as freshwater or arable land. Microalgae are (i) fast-growing microorganisms that double in less than a day, (ii) capable of achieving high biomass productivities above 100 t/ha year (by dry weight) and (iii) mainly use sunlight as the energy source, with efficiencies as high as 10 %. For these reasons, they are considered fundamental for the development of sustainable processes that contribute to the global bioeconomy [8]. However, these are optimistic values are really difficult to achieve at large scale: under real outdoor conditions the duplication time reduces up to two days, the biomass productivity decreases up to 40 t/ha year, and the photosynthetic efficiency decreases up to 3%.

Here, the major factors determining the performance of microalgae-related processes are reviewed, followed by an analysis of the most relevant contributions made by microalgae to the bioeconomy. This

* Corresponding author.
E-mail address: facien@ual.es (F.G.A. Fernández).

https://doi.org/10.1016/j.nbt.2020.11.011

Available online 26 November 2020