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Microalgae Biomass Toward the End of the Food or Fuel Global Battle

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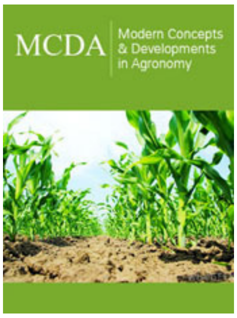

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Abstract

The high content of lipids, proteins, and carbohydrates in microalgae makes them valuable, sustainable, and environmentally friendly feedstock that can face the exponential demand for nutritious food and cleaner fuels. This article presents relevant information on the ability of microalgal biomass to solve the current food or fuel production dilemma. It also reports on the need to continue developing research and novel technologies for the optimal use of microalgae.

Keywords: Microalgal biomass; Food security; Third generation biofuels; BECCS

Introduction

The growing dependence on energy and food exacerbates the debate on what priority world markets should assign to balancing price volatility without neglecting the care of human health and natural resources. However, the main driving force of the market is supply and demand, suggesting that more is produced than generates more profit [1]. The fuel or food crossroads began with the global agricultural commodity price crisis of 2007-2008. From then on, a shift was made to establish a new vision for renewable energy generation (biofuels) [2]. Biofuels (biodiesel, bioethanol, biogas, and biohydrogen) are bio-based products found or extracted from natural resources, such as wood and bagasse, or chemically transformed from a biomass to form products such as charcoal, bio-oil, ethanol, and biogas. Depending on the type of feedstock and production technologies, biofuels have been classified into first-generation, second-generation, and third-generation biofuels [3]. Microalgae oil is the only one with the potential to displace conventional diesel. Unlike other oil crops, microalgae have a lipid yield 10-800 times higher than terrestrial biomass. However, for algae to become an economically viable platform to replace petroleum, improvements must be implemented in the isolation of oleaginous strains, production management, harvesting, oil extraction and transformation to fuel, co-product development, refining, and utilization of residual biomass [4].

Furthermore, the planet's capacity to produce biomass is limited because it is subject to biophysical, socioeconomic, and political conditions [5]. And the consequent increased biofuel production may cause food prices to escalate.

Therefore, it is imperative to search for and use non-conventional biomass technologies and sources to mitigate the exponential demand for energy without affecting food security and, at the same time, mitigate massive environmental impacts.

Recently, technology based on Bioenergy with Carbon Capture and Storage (BECCS) generation has been positioned as a novel technology with environmental benefits that can address the challenges of global fuel and food demand [6]. In this context, microalgae are a potentially abundant supply of biomass with food and bioenergy applications, with the ability to sequester carbon effectively and without the need to exploit arable land. Furthermore, as a feedstock, microalgae have considerable advantages over plants; they have a high rate of lipid productivity per hectare yield and can be grown in shallow lagoons, in ponds on marginal lands, or closed ponds. In addition, wastewater can be used for microalgae growth, which is fast and with short harvest cycles, ensuring high productivity and a constant supply of raw materials. Furthermore, its high photosynthetic efficiency and easy cultivation has led to high rates of oxygen generation and CO_2 consumption. All the above translates into reduced anthropogenic CO_2 levels, the use of non-cultivable land, and decreased waste production [7].

On the other hand, microalgae are also a promising source of nutritional biomolecules such as proteins, lipids, and carbohydrates for the food industry and as animal feed. Numerous components have been reported in microalgae, such as a) essential amino acids, b) antioxidants, c) chlorophylls and carotenoids, e) folic acid, f) polysaccharides, g) polyunsaturated fatty acids (PUFA), h) triglycerides, and i) vitamins [8]. Due to their high nutritional value, microalgae species such as *Arthrospira platensis, Chlorella, Dunalliela salina, Haematococcus pluvialis, Schizochytrium sp*. are recognized within GRAS (generally recognized as safe) list of the US Food and Drug Administration (FDA) and are used as additives in pasta, bread, milk, cookies, etc. [9]. In addition, the bioactive compounds from microalgae have shown antimicrobial, antiviral, and antifungal properties, as well as neuroprotective and immunostimulant activities [10].

In a world where during the Covid-19 pandemic, efficient immune boosters and health-promoting and disease-preventing substances are frantically searched after, microalgal metabolites have a vast scope for application. Therefore, a microalgae production platform where multiple industrial wastes can be utilized for bioprocesses' sustainable development is indispensable. However, still large-scale microalgae cultivation, harvesting, drying, biomass pretreatment, and the appropriate technology for the extraction of metabolites and biofuel production from microalgae have high downstream processing costs and are limitations for the optimal utilization of microalgae compounds. Hence, for a clean and sustainable future where microalgae biomass can be fully utilized for food and biofuel production, new and novel biorefinery techniques are needed to exploit all products obtained from microalgae, leading to the highest amount of products and by-products, with a minimum amount of waste generation and a maximum return on investment for further processing [11].

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