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Review

Biofuels as a sustainable energy source: An update of the applications of proteomics in bioenergy crops and algae☆

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ABSTRACT

Sustainable energy is the need of the 21st century, not because of the numerous environmental and political reasons but because it is necessary to human civilization's energy future. Sustainable energy is loosely grouped into renewable energy, energy conservation, and sustainable transport disciplines. In this review, we deal with the renewable energy aspect focusing on the biomass from bioenergy crops to microalgae to produce biofuels to the utilization of high-throughput omics technologies, in particular proteomics in advancing our understanding and increasing biofuel production. We look at biofuel production by plant- and algal-based sources, and the role proteomics has played therein.
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Contents

1. Introduction

The demand for sustainable energy ranks as one of the most pressing concerns of the 21st century. With dwindling fossil fuel reserves, rising crude oil prices and heightening fears over the effects of climate change, there is an urgent need to promote the use of renewable/alternative energy sources for a sustainable future [1–5]. One alternative to fossil fuels is nuclear powered energy, however, recent catastrophic events as seen in Chernobyl [2] and Fukushima [3], have cast serious doubt over the safety of nuclear energy. Before we move on to the focus of this review — bioenergy — it is important that we know the definition of sustainable energy. Sustainable energy is the sustainable provision of energy that meets the needs of the present without compromising the ability of future generations to meet their needs [6]. Such an approach is avidly being pursued at the level of national and regional policies aimed towards the reduction of fossil fuel emissions, promotion of sovereign energy, security stimulation of job creations and to drive overall economic developments [7]. Towards this end, significant investments are being made in the renewable energy sector, resulting in many promising advancements being made in the fields of solar, wind, geothermal, and biofuel technologies. In the scope of this review the role of biofuels, as a sustainable energy alternative, will be discussed, with particular focus on the role that proteomics and other emerging 'omics' technologies can play in its further development. Here it will be shown, with some examples that proteomics and other related post-genomics techniques namely transcriptomics are beginning to make a vital contribution to the development of our current knowledge and understanding several key bioenergy feed stock plants and algae.

2. Bioenergy — a sustainable energy source

Bioenergy refers to energy produced from biological materials, specifically photosynthetic organisms such as green plants, grasses, and algae. Bioenergy is currently the only alternative energy source able to supply liquid transportation fuels. This can be achieved by i) using fermentation of sugars to produce bio-ethanol (feedstock: sweet *Sorghum*, sugar cane, sweet potato, sugar beet etc.), ii) lignocellulosic biofuels that use all the plant material (feedstock: straw, corn stover, switch grass, poplar, etc.), iii) lipids derived from algae and other oil crops (feedstock: *Jatropha*, *Pongamia*, castor, sunflower, oil palm, etc.) after trans-esterification process, and iv) through the use of syngas obtained from gasification of biomass [8–14]. To date, liquid biofuels have been produced mainly in the USA, Brazil and several European nations. Further, there is a regional preference for biofuel types, with bio-ethanol produced in American and Asian countries, while biodiesel is preferentially produced in European nations and parts of Africa and Asia.

In the past decade, considerable research has been carried out to understand molecular mechanisms of biofuel plants. Rapidly developing post-genomics, systems biology approaches such as transcriptomics [15], proteomics [16], and metabolomics have become essential for understanding how plants respond and adapt to changes in their environment and yield improvement. The utilization of such high-throughput approaches will lead to the production better and high-yielding biomass feedstock which will eventually facilitate the acceleration of production and commercialization of biofuels.

2.1. *Plant based: Sorghum and others*

Cultivated *Sorghum* (*Sorghum bicolor* L. Moench), the fifth most important grain crop in the world, is a highly versatile cereal that has been selectively bred into four main varieties: grain, sweet stems, high-energy fiber, and for multi-purpose [17]. While the grain sorghums are grown mainly for household food security, the other *Sorghum* types are sought after for their commercial value. *Sorghum* fiber for example can be utilized in the manufacture of various paper and cardboard products [17]. On the other hand, the sweet-stemmed varieties are highly valued for their sucrose content, which is used to produce syrup and bio-ethanol [18]. The multi-purpose

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