Identification and selection of algae for food, feed, and fuel applications 12

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1 INTRODUCTION

There is a global revolution afoot that relates to food production, social and environmental sustainability, health and nutrition, and economic development. With historical roots in ancient China, Japan, and many coastal regions throughout the world, algae in all forms are experiencing a dynamic renaissance (Aaronson, 1986; Xia and Abbott, 1987; Turner, 2003; Mouritsen, 2013). Since its long-lived history on the earth as a progenitor of early oxygen production, which is estimated to be around 2.5–3 billion years ago (Margulis, 1981; Christaki et al., 2011), algae have contributed enormously to the evolution of mankind. As a source of sustenance for other organisms in the primordial soup, and throughout its own evolution, ultimately giving rise to terrestrial plants (De Clerck et al., 2012), algae have diversified and adapted. Algae are aquatic organisms, capable of converting sunlight and CO2 into chemicals through photosynthetic activities (Tomaselli, 2007). Worldwide, more than 200,000 different species have been isolated and classified according to their color, size and shape, chemical characteristics, cell wall constituents, and intracellular composition (John et al., 2003; Mata et al., 2010). Their dimension ranges from micrometers to meters, providing an obvious size division between microalgae and macroalgae. The latter, commonly known as seaweed, are multicellular organisms similar to plants, growing predominantly in the marine environment. Microalgae, or phytoplankton, include small unicellular organisms found in water, representing the primary source of food for most aquatic fauna and causing seasonal algal blooms in rivers, lakes, and ponds under eutrophic conditions. Early hunter–gatherers benefited from the nutritional and medicinal qualities of algae as well as from the rich habitats associated with them. Analysis of ancient remnants of a number of species of algae excavated in southern Chile and dated to approximately 14,000 years BP suggests it was used in food and medicine (Dillehay et al., 2008). There is no doubt that a diet rich in the essential amino acids, particularly the super unsaturated omega-3 fatty acids, most importantly docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), contributed to the early development and growth of the human brain. Nowadays, algae are commercially cultivated for the production of a number of different goods, including human and animal food additives and biochemicals. However, algae biomass has the potential to deliver a wider range of products, which include bioenergy, biofuels, and biobased products (bioplastics, biocosmetics, biosolvents). The special gelling and lubricating properties of seaweeds have also been exploited. Agar, and then carrageenan, which had traditionally been used as a thickener in cooking, became important gelling agents utilized in medicine and in science (Marshall et al., 1949). The extensive rheological properties of the sulfated polysaccharide components of algae are indicative of its value as a superior biolubricant, which is stable over a range of temperatures, pH values, and salinities (Arad et al., 2006). Moreover, carrageenan from macroalgae, which is a nontoxic, natural, water-based lubricant, provides an important ingredient to the personal care industry (http://www.oceanusbrands.com). Their high sugar content and notable biochemical composition make them an incredible substitute for the conventional crops (soybean, grains, and starchy substrates) currently utilized in bioenergy production (Holdt and Kraan, 2011). Also, algae do not require land; their availability to grow in any kind of water source (marine, fresh-, or wastewater) avoids competition with conventional food crops that require arable land and freshwater (John et al., 2011). Various values attached to algae mean it can be used as a commodity to trade for other goods. This utilization of biomass for agriculture and industry means that algae became an important item of commerce, and it still contributes to the economic development and sustainability of many coastal communities.