Chapter 1
Introduction

Om V. Singh and Anuj K. Chandel

The ever-increasing appetite of energy relies upon the use of unsustainable conventional resources. Even though, the nature offers abundant *renewable* resources to replace unsustainable sources, the technology readiness levels and compatibility with existing distribution networks remains a challenging issue. Multiple renewable energy resources such as solar, tidal, hydrothermal, ocean thermal, and wind energy have ben explored as alternative resources, however each comes with its limitations. Lignocellulosic biomass is one of the most immediate source of energy that can serve as potential alternative of fossil fuel (Singh and Harvey 2008; Chandel and Singh 2011; Chandel and Silveira 2017). After successfully introducing Edition one of "Sustainable Biotechnology: Sources of Renewable Energy" in 2010, here we continued to extend our efforts towards bridging the technology gap and focusing on other critical aspects of lignocellulosic biomolecules. We also considered the respective mechanisms regulating the bioconversion of liquid fuels into energy and value-added products of industrial significances.

The lignocellulosic biomass (LB) is an inexpensive feedstock. Due to the nature of availability, it is an easily accessible as agricultural and forest residue, municipal wastes etc., and has potential to act as a valuable substitute for fossil fuels. Structurally, LB contains significant amounts of polysaccharides that can be subjected to microbial fermentation into energy and other value-added products of industrial significance. Considering the enormous potential of LB, in Chap. 2*, Sharma* et al. provided strategies for bio-refining and valorization of biomass to value-added prod-

O. V. Singh (✉)
Technology Science Group, Inc., 1150 18th Street NW, Suite 1000, Washington, DC 20036, USA
e-mail: osingh@tsgusa.com

A. K. Chandel
Department of Biotechnology, Engineering School of Lorena (EEL), University of Sao Paulo (USP), Estrada Municipal do Campinho, s/n° 12.602-810, Lorena, Sao Paulo, Brazil
e-mail: anuj.kumar.chandel@gmail.com; anuj10@usp.br

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ucts. The chapter also emphasizes on recent advancements in the fields of pretreatment, metabolic engineering, enzyme production and fermentation that would help in developing a suitable technology which could replace the deteriorating effects of fossil fuels. Further, *Bhatia* et al. in Chap. 3, give the matter a more detailed consideration by elaborating on biotechnological advancements in cellulosic ethanol production from lignocellulosic biomass. In continuation, *Adak* et al. in Chap. 4 provides a detail description of weedy biomass and other unconventional lignocellulosic wastes for sustainable production of biofuel.

Earth's most plentiful and renewable energy resources typically include sunlight, wind, geothermal heat, water (rivers, tides and waves), and biomass. All of these are suitable for the generation of electricity but biomass is the current main renewable feedstock for the production of "liquid" fuels—typically ethanol, and biodiesel and possibly to include butanol, hydrogen and methane. However, the efficient and cost-effective production of bioethanol from various lignocellulosic biomasses is depending on the development of a suitable pretreatment system and technological aspects of bio-engineered feedstock. *Lopresto* et al. in Chap. 5 interpreted the existing pretreatment methods of bioengineered feedstock that can be effectively utilized via biocatalytic hydrolysis. In addition to technological aspects of lignocellulosic conversion into biofuels, *Hilares* et al. in Chap. 6 discussed how high cost of 2G ethanol process can be supplemented by producing biopolymers, biopharmaceutical, nutrients, pigments, surfactants, and other biochemical using varying fractions of lignocellulosic biomass. The concept was named as "Bio-refinery" that can contribute with the economic viability of current state of bio manufacturing of specialty chemicals. *Unrean P* continued the discussion in Chap. 7, provided techno-economic analysis to compare different upstream process configuration for lignocellulose-to-ethanol process and to determine the cost effectiveness process option suitable for commercialization based on minimal selling price of ethanol produced.

Novel enzyme mediated bioconversion of biomass can address the multiple challenges of effective hydrolysis of lignocellulosics. Discovering new and sustainable resources, which can help refuel industrial biotechnology. The adverse environmental conditions which normal earth microbiota do not tolerate, offer potential sites to explore specific sets of microorganisms designated as 'Extremophiles'. The discovery of these microorganisms has enabled the biotechnology industry to innovate unconventional bioproducts i.e. 'Extremolytes' (Schiraldi and DeRosa 2002; Singh 2012; Beeler and Singh 2016). In Chap. 8, *Sharma and Vasanth* provided an overview of thermophilic habitats. The applications of extremophiles and their products, extremozymes, with their possible implications with lignocellulolytic activity are also discussed broadly.

Studies show that different types of biomasses are being used for production of sustainable fuel with the help of biofuel enzymes. According to the BCC Research report, Global Markets and Technologies for Biofuel Enzymes (EGY009B), the global market for biofuel enzymes have higher projection in the future ahead. *Sharma and Sharma* in Chap. 9 discussed multiple applications of enzymes in sustainable liquid transportation fuels production. In continuation, several enzymes including lipases are known for the hydrolytic activity on carboxylic fatty ester bonds. There is broad industrial interest in lipases due to their applications in a wide array of value-added products of commercial significance such as detergents, cleaning agents, pharmaceuticals, food industries, and for biodiesel production. In Chap. 10, *Cortez* et al. discussed the realm of lipases in biodiesel production.

Technological implementations have always been amazed multidisciplinary areas of science. Nanotechnology represents one of the most fascinating techno-scientific revolutions ever undertaken in various sectors including biofuel and bioenergy. Varying nanomaterials have been explored to play important role in energy fields due to their unique structure, relatively high specific area and comparatively good efficiency of lighting and heating (Ansari and Husain 2012; Singh 2015; Rai and da Silva 2017). In Chap. 11, *Ingle* et al. discussed recent trends and applications of nanotechnology in biofuel production.

The agro-industrial waste is defined as the organic and non-organic residues generated by the activity of the production and processing or raw materials from agricultural, livestock, and dairy industries. Utilization of these raw products could potentially reduce the overall cost of biofuel production (Balan 2014). In Chap. 12, *Boura* et al. presents different aspects of the production of ester-based biofuel from agro-industrial wastes emphasizing on the production of 2nd generation biofuel. The anaerobic digestion is the most prominent bioenergy technology and has been profitable alternative providing a sustainable solution to treat organic wastes and reduce the greenhouse gases emission. *Montanez-Hernandez* et al. in Chap. 13 provided sustainable production of biogas as potential biofuel from renewable sources.

Among value-added products of commercial significance, Polyhydroxyalkanoates (PHAs) have received substantial attention as an alternate of conventional non-biodegradable plastic. Microorganisms especially bacteria and cyanobacteria have the ability to synthesize PHAs granules intracellularly as carbon and energy storage compounds. In Chap. 14, *Singh* et al. provides microbial molecular mechanism for biogenesis of PHA as green plastic molecule. Further, *Muniyasamy* et al. in Chap. 15 presents synthesis of biopolymer and aspects of their biodegradability. This chapter also discusses the management of conventional plastic materials to secure the environment.

The technological advances have enabled an effective use of natural sources to obtain clean energy, thus reducing emission of gaseous pollutants into the environment. The use of microalgae as raw material to obtain biofuel has been proved promising. Thus in Chap. 16, *Reis* et al. discussed the applications of microbial consortia in a bio-refinery context and provided insight understanding of the importance of artificial lichens. In continuation, *Goncalves and Silva* in Chap. 17 proposed green microalgae as substrate for producing biofuel and chlorophyll as value-added product of commercial significance in the bio-refineries.

Apart from biofuel, the sericulture is another important sustainable agro based industry that plays pivotal role in the rural and urban economy. Similar to biofuel, the sericulture utilizes lignocellulosic biomass as a potential resource of raw material for profitability. In Chap. 18, *Thirupathaiah Y* provided a unique contribution to this book explaining the future and perspectives of potential applications of enzymes used in the sericulture sector of environmental sustainability.

This book "Sustainable Biotechnology: Enzymatic Resources of Renewable Energy" is a collection of articles elucidating several broad-ranging areas of progress and challenges in the utilization of sustainable resources of renewable energy, especially in biofuels. After the release of "Sustainable Biotechnology-Resources of Renewable Energy" in 2010, this book comes just at a time when industrialists are accelerating their efforts in the exploration of alternative energy and other value-added products of commercial significance to establish long-term sustainability in bio-refineries. Apart from liquid fuel this book also provides in-sights of value-added products, which may help in revitalizing the biotechnology industry at a broader scale.

We hope readers will find these articles interesting and informative for their research pursuits. It has been our pleasure to put together this book with Springer press. We would like to thank all of the contributing authors for sharing their quality research and ideas with the scientific community through this book.

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