EDITED BY
SANTOSH KUMAR UPADHYAY
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# BIOPROSPECTING OF PLANT BIODIVERSITY FOR INDUSTRIAL MOLECULES

WILEY

# Bioprospecting of Plant Biodiversity for Industrial Molecules

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*Edited by*

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# Preface

Nature has the reservoir for all the desired molecules in the form of biodiversity that includes microbial, animal, and plants. Bioprospection is very well-established method for the identification and isolation of new active molecules of desired activity. Researches are being conducted to exploit the biological resource for obtaining biomolecules of pharmaceutical, bioceutical, agricultural, bioremediation, etc. significance. The exploitation of bioactive significance in the natural compounds in the biosphere is required to be intensified with systematic and sustainable approaches. The expedition and validation of the scientific parameters in the ethnic knowledge, preservation of bioresource, and biotechnological advancement in the generation of efficient biological systems, keeping in mind the approach of societal development exploitation with nature's protection, are the current demand in scientific investigations.

Bioprospection is the exploration of economic potential in the biological resource mostly in terms of nutraceutical value. In recent decades, substantial attention has been given on a variety of bioresources for bioprospecting. For example, macro- and microalgae have been demonstrated to be a biomass value of neutraceutical, pharmaceutical, food, biomedical, bioenergetic importance.

Plants are a crucial biological component of the biosphere in the earth. The plant resource has served the humankind in several ways by providing food, feed, medicine, nutraceuticals, shelter, etc. About 3.9 lakh known plant species make the animals and other organisms' life possible at the earth. Plant bioprospecting is being performed since the existence of human life on the earth. Extensive investigations have been done to explore several phytochemicals, pharmaceuticals, antioxidants, etc. There is a need to develop plant products with prebiotic properties and with high bioavailable mineral micronutrients. A rich cultural knowledge associated with multifarious health beneficial aspects of plants is available in different parts of the world. Many plants of cosmetic and perfumery importance have been shown to be of great economic value. The plants grown for production of spices and condiments have significant societal and medicinal merits. Many lower plants have been demonstrated to exhibit potential in biopesticide development. Furthermore, this is an era of secondary agriculture by the valorization of the abundant residual plant biomass.

We firmly believe that this book will be an essential repository in obtaining the holistic knowledge of plants bioprospecting. The compiled information will be useful to academicians and researchers in augmenting their understandings on the aspects mentioned earlier.

## About the Editors

Source: Santosh Kumar Upadhyay

**Dr. Santosh Kumar Upadhyay** is currently working as an Assistant Professor in the Department of Botany, Panjab University, Chandigarh, India. Prior to this, Dr. Upadhyay was DST-INSPIRE faculty at the National Agri-Food Biotechnology Institute, Mohali, Punjab, India. He did his doctoral work at the CSIR–National Botanical Research Institute, Lucknow, and received his Ph.D. in Biotechnology from UP Technical University, Lucknow, India. He has been working in the field of Plant Biotechnology for more than 14 years. His present research focuses in the area of functional genomics. He is involved in the bioprospecting and characterization of various insect toxic proteins from plant biodiversity and defense and stress signaling genes in bread wheat. His research group at PU has characterized numerous important gene families and long noncoding RNAs related to the abiotic and biotic stress tolerance and signaling in bread wheat. He has also established the method for genome editing in bread wheat using CRISPR–Cas system and developed a tool SSinder for CRISPR target site prediction. His research contribution led the publication of more than 58 research papers in leading journals of international repute. Further, there are more than 5 national and international patents, 22 book chapters, and 6 books in his credit. In recognition of his substantial research record, he has been awarded NAAS Young scientist award (2017–2018) and NAAS-Associate (2018) from the National Academy of Agricultural Sciences, India, INSA Medal for Young Scientist (2013) from the Indian National Science Academy, India, NASI–Young Scientist Platinum Jubilee Award (2012) from the National Academy of Sciences, India, and Altech Young Scientist Award (2011). He has also been the recipient of the prestigious DST-INSPIRE Faculty Fellowship (2012) and SERB-Early Career Research Award (2016) from the Ministry of Science and Technology, Government of India. Dr. Upadhyay also serves as a member of the editorial board and reviewer of several peer-reviewed international journals.

**Dr. Sudhir P. Singh** is currently Scientist at the Center of Innovative and Applied Bioprocessing (CIAB), Mohali, India. He has been working in the area of molecular biology and biotechnology for more than a decade. Currently, his primary focus of research is gene mining and biocatalyst engineering for the development of approaches for transformation of agro-industrial residues and under or unutilized side-stream biomass into value-added bio-products. He has explored the metagenomic resource from diverse habitats and developed enzyme systems for catalytic biosynthesis of functional sugar molecules such as D-allulose, turanose, fructooligosaccharides, glucooligosaccharides, 4-galactosyl-Kojibiose, xylooligosaccharides, levan, dextran biosynthesis, etc. Dr. Singh has published over 55 research articles, 4 review articles, and 4 books (edited). Further, he has five patents (granted) to his credit as an inventor. He has been conferred International Bioprocessing Association–Young Scientist Award (2017), School of Biosciences–Madurai Kamraj University (SBS-MKU) Genomics Award (2017), Professor Hira Lal Chakravarty Award, ISCA, DST, (2018), and Gandhian Young Technological Innovation Award to team (2019).

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# 1

# An Introduction to Plant Biodiversity and Bioprospecting

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## 1.1 Introduction

There is an extensive diversity in life that has been disentangled and organized into coherent units called taxa. The five kingdom system of classification has simplified the life forms into five groups. These groups orchestrate information concerning a wide variety of characteristics such as morphological, genetic, metabolomic, ecological, etc. Kingdom Plantae is one of these five kingdoms that consists of all the plant forms on earth and is rich in its metabolomic characteristic. This kingdom is highly diverse and is composed of both seed bearing (Phanerogams) and seedless (Cryptogams) plants forming five broadly classified groups, i.e. algae, bryophytes, pteridophytes, gymnosperms, and angiosperms, which are evolutionarily related. Each of these groups consists of hundreds of thousands of known species, which in turn consist of a variety of chemicals called metabolites or more specifically secondary metabolites. These secondary metabolites or natural products are believed to possess certain biological activities that are used by the producer for their environmental and competitive fitness. Progressively, it became a paradigm that all the plants possess some potent biologically active substance/s that could have great commercial/therapeutic value to humans. It has been often argued that the currently available knowledge regarding the chemical diversity of the plant biome represents only a fraction of that diversity, hence paving way toward further explorations. Thus, their rich metabolomic diversity and its knowledge increase the opportunity for humans to utilize plants as a key resource for bioprospecting.

## 1.2 What is Bioprospecting

Let us widen our imaginations and visualize an underdeveloped rural village in India, where an old wise man is treating a sick man with his self-made herbal concoction comprising

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the roots of some wild plants, or, let us visualize him trying to squeeze a stream of juice from a bunch of leaves upon a snake-bitten area of a person's leg. Just after a few days, the concoction healed the patient of his fever and inflammations, and the juice rescued the patient from snake venom. Therefore, it could be assumed that the concoction made from the herbs might consist of metabolites having antimicrobial properties, and the juice of the leaves might consist of chemical/metabolite that had antivenom properties. Now again, let us visualize a group of scientists walking inside the same village, talking to this old wise man, collecting these herbs, and returning to their respective laboratories, where they try to screen these herbs for the presence of active compounds having antimicrobial or antivenom properties using modern technologies. This whole procedure of exploring biologically important/useful compounds from natural resources lays down foundations to the science of "bioprospecting." The former half of our visualization could be considered as "traditional bioprospecting," and the latter half of it could be considered as "modern bioprospecting." Traditional bioprospecting can even be traced back to as old as the bronze age. In 1991, a 5300-year-old corpse of an iceman "Otzi" was discovered in the Tyrolean Alps and was found to have a whipworm (*Trichuris trichiura*) infection. Surprisingly he was already equipped with the corresponding anthelmintic medicine, which is the fruiting body of the fungus *Piptoporus betulinus* [1, 2]. Thus, the utilization of natural resources for the interest of humans is as old as humankind itself, and what we follow today is just a modern and sophisticated version of this science.

The term "bioprospecting" was initially described by Reid et al. [3] as the science, where biological systems are screened for novel components that are of industrial, commercial, or scientific value. It includes the hunt for biological products that possess characteristics interesting to humankind. These characteristics could be considered to have great potentials in the field of therapeutics, agriculture, cosmetics, etc. Although the utilization of the biologically active properties of plant/animal extracts for various purposes was seen even before thousands of years, bioprospecting as a science for commercial and economic gains was introduced and progressed in and around the twentieth century. In 1958, vinblastine and vincristine, two therapeutic agents for cancer, were developed from the rosy periwinkle plant in Madagascar. These therapeutic agents were researched and manufactured by the company Eli Lilly with cues from the local shaman spiritual herbalists [4]. Further, prospecting in the wild has warranted many therapeutic agents, such as antibiotics and several other anticancer drugs. The modern biochemists and pharmacologists have been busy seeking ways to block or enhance the function of a target protein molecule for a cure to a particular disease. The classical combinatorial chemistry has its limits in the synthesis of new compounds when it comes to the exceedingly large and diverse number of the target proteins that are being identified. The diverse and continuously evolving structures of the natural products of Mother Nature may be a possible solution to these problems. Even as the rational drug designing with the help of combinatorial chemistry is becoming more important, natural products have been valuable for pharmaceutical companies owing to their wide structural diversity and their excellent adaptation to biological active structures [4]. A fast exploration of any medicine cabinet or a cosmetic shop directly indicates the share of bioprospecting natural products, by astute businessmen in building the global economy.

Chemicals, genes, and designs are the three major sources of motivation that biodiversity extends to contemporary scientists. Thus, the science of bioprospecting finds its