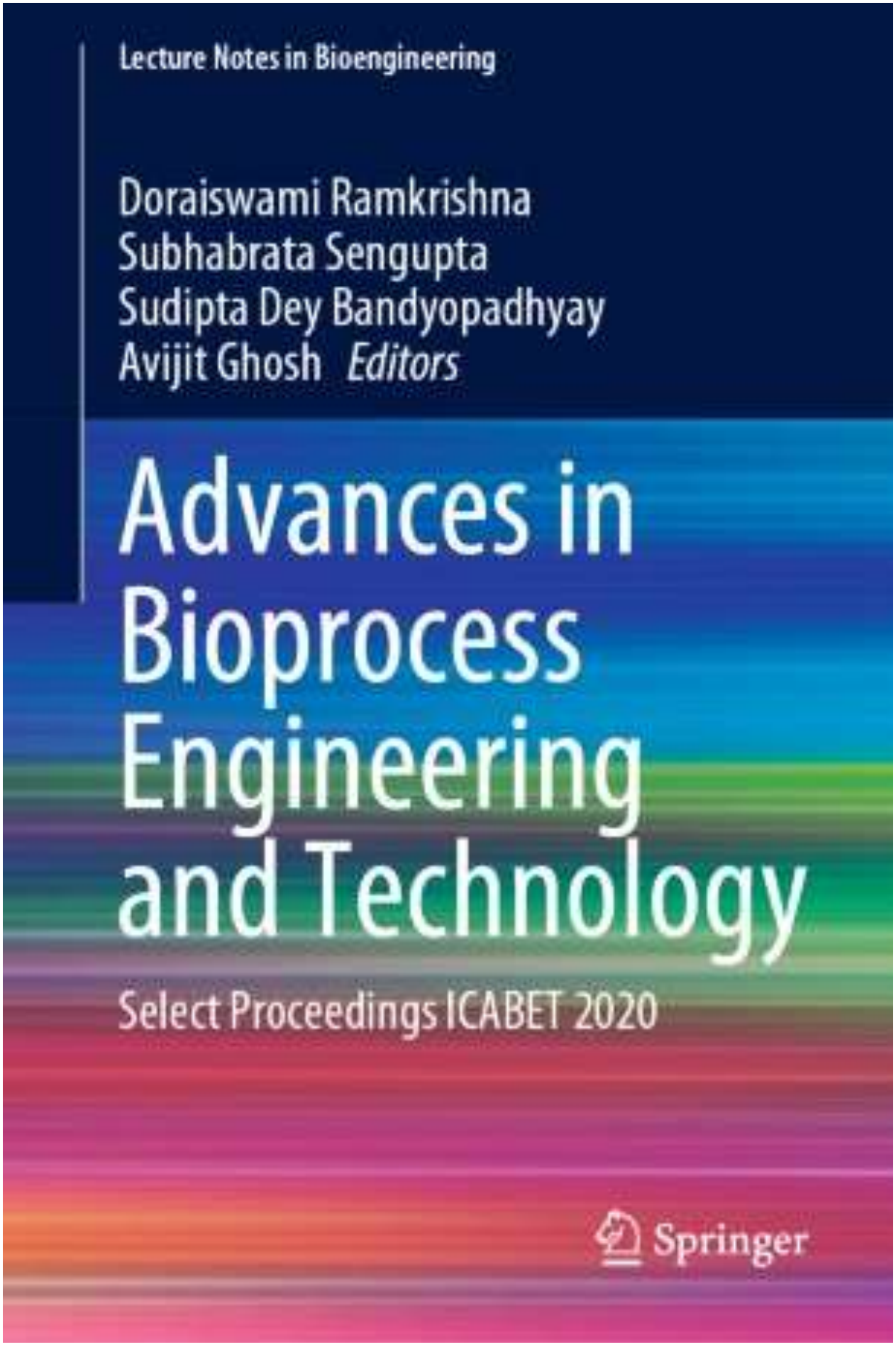
Lecture Notes in Bioengineering
Doraiswami Ramkrishna
Subhabrata Sengupta
Sudipta Dey Bandyopadhyay
Avijit Ghosh Editors
Advances in Bioprocess Engineering and Technology
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Editors

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ISSN 2195-271X ISSN 2195-2728 (electronic)
Lecture Notes in Bioengineering
ISBN 978-981-15-7408-5 ISBN 978-981-15-7409-2 (eBook)
https://doi.org/10.1007/978-981-15-7409-2

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

Bioprocess engineering and technology is primarily associated with the commercial application of living organisms on large scale. Commercialization of biological discoveries requires substantial engineering work. Bioprocess engineering and technology is an interdisciplinary subject which brings disciplines of biology and engineering on the same platform. A large number of disciplines like microbiology, genetics, chemistry, biochemistry, engineering mathematics, modelling and simulation and computer science have contributed significantly in achieving the target of delivering product and process to the society. In this spectrum, a large number of research findings are accumulating every day from all these disciplines. Many of these findings require proper scrutiny to find their place to the initiative for bioprocess development for future commercialization. The collection of data for scrutiny and review are primarily required by the experts for any further promotion of bioprocess to the next phase. It is true that global young generation is trying hard to generate data in this domain and aimed at the production of biopharmaceuticals, bio fuels and, development of biosensors, pollution control technologies, such as, mineral recovery, bioremediation of soil and water and so on. With the objective to assemble these data, Heritage Institute of Technology, Kolkata (HITK), India, hosted the 1st International Conference on Advances in Bioprocess Engineering and Technology on 20–22 January, 2016. The grand success in the effort tempted the institute to arrange second such conference: 2nd International Conference on Advances in Bioprocess Engineering and Technology on 20–22 January, 2020 (ICABET 2020). Department of Biotechnology and Department of Chemical Engineering of HITK suceessfully organized the conference. The conference aimed to highlight areas like fermentation technology and bioreactor; environment and agriculture; food, pharmaceutical and health care; sustainable energy; nanomaterials and nanotechnology. Each session was well participated, particularly by young generation of researchers. Many of them got the opportunity to meet and discuss

their research with expert seniors. I personally appreciate the objective and success of the conference and hope continuation of such conference in future with balance participation of senior and junior researchers.

Kolkata, India Subhabrata Sengupta

Introduction

Biotechnology covers a broad segment of science and technology and commands worldwide research because of its potential impact on the improvement of quality of life. A bioprocess is the technology to obtain desired product or process with the help of living cells or their component or products like enzymes. Bioprocess engineering is a sub discipline within Biotechnology that is necessary for the translation of discoveries of this field into usable products, and processes deliverable to the society. Bioprocess technology was initiated in the first half of 20th century with the production of penicillin and citric acid by classical fermentation processes and later on fortified significantly by recombinant DNA technology, plant and mammalian cell culture techniques. Nano biotechnology, as a promising technology is also progressing, classically for cancer targeted drug development. Bioprocessing today became a major part of biotechnology domain involved in the production of huge number of human health care products, as well as products for agriculture, industries, and food processing. Apart from these, development of biosensors, detoxification of environmental pollutants, biofuel generation are major focused research in this domain.

In earlier days putting the biology in bottle took much longer time. It took almost 15 years for penicillin from discovery to application as drug. Glucose isomerase for high fructose syrup commercialization took 10 years or more. Products, that are now under development, demands novel bioprocess techniques which is more efficient and more economic, so as to reduce the time gap between discovery and application. Bioprocess Engineering by its very nature is interdisciplinary subject and thus requires more coherent approach to cross disciplinary research and education. Although bioprocess industries have successfully translated many basic research in biological science and molecular biology into valuable products, but more intense research is needed for the development of more effective biopharmaceuticals for many catastrophic diseases like cancer, heart diseases and kidney diseases. A second generation products should be available whose price-cost difference is low. Bioprocess for the generation of alternative energy source like ethanol, biohydrogen, biomethane, bioelectricity from renewable biomass should reach to consumer within a reasonable time period at affordable cost. Utilization of

renewable resources for production of renewable energy through bioprocess route has tremendous impact on lowering our energy budget. At the juncture of novel process development, the cost effectiveness and cost input for a bioprocess should be given importance for successful delivery to the society. Bioprocess engineering must carefully consider more economic route for the production, not only for new products but also for older products so that the larger fraction of society gets benefitted.

The major challenge in achieving optimal benefit from the technology is to bring about the synergistic combination of skills of biology, biotechnology, chemical engineering, bioprocess engineering and computer science on a single platform. In future, nanotechnology and information technology will see substantial progress and expansion of bioprocess engineering and technology.

Finally, it may be added that engineering in the traditional sense of scale up and cost reduction is not enough. Significant advances and efforts are required for implementing new ideas other than traditional pathways. An academic policy maker should take more responsibility of educating young generation of students in different cross fields of bioprocess engineering in a comprehensive manner from a single platform.

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About the Editors

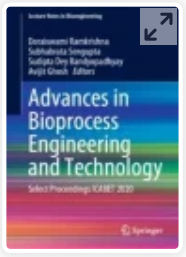
Prof. Doraiswami Ramkrishna is currently Harry Creighton Peffer Distinguished Professor of Chemical Engineering at Purdue University. He obtained B. (Chem) Eng., from University of Bombay (1960) and Ph.D. in Chemical Engineering from University of Minnesota (1965). Prof. Ramkrishna's research group is motivated by ideas in the application of mathematics to solving problems in chemical and biochemical reaction engineering, biotechnology and biomedical engineering. He is the recipient of many prestigious Awards and Honors, a few of them are: Award for Outstanding Graduate Faculty Mentor (2019), Balwant S. Joshi Distinguished Professorship, ICT, Mumbai, (2017–2018), Sigma Xi Faculty Research Award (Purdue Chapter, 2013), College of Science, Team Award, (2012), Foreign Fellow, Indian National Academy of Engineering (2011), M. M. Sharma Distinguished Professor, Institute of Technology, University of Mumbai (2010), Mumbai Institute of Technology Platinum Award (2009), Member, US National Academy of Engineering (2009), Fellow of the American Institute of Chemical Engineers (2008) and many more. He has published more than 260 papers in international journals and authored 8 books and book chapters. More than 45 students were awarded PhD under his guidance. He has served as a Consultant to General Mills, Inc. Minneapolis, Minnesota, Pillsbury Co., Minneapolis, MN, and to American Oil Company, Naperville, IL, and Ciba-Corning, MA. He is also Member of Technology Advisory Board (2005), Member Advisory Council to Pacific Northwest National Laboratory, Richland, WA, on Microbial Community Initiative (2010–2013). He has carried out consultation activity with Pillsbury Company, Amoco, Ciba-Corning, Abbot Laboratories and Eli Lilly. He is the First Chairman of Area 10D on Applied Mathematics of CAST Division of the American Institute of Chemical Engineers (1987–1991). He has Chaired several sessions in the annual meetings of the A.I.Ch.E. on applied mathematics. He is on the Editorial Board member of Journals: Latin American Journal of Chemical Engineering, International Journal of Applied Engineering Research, The World Journal of Chemical Engineering, Current Opinion in Chemical Engineering, International Journal of Chemical Engineering. He was honored with Guest Editorship of journals: Chemical Engineering Communications, Journal of Biotechnology, and Processes.

Prof. Subhabrata Sengupta is former scientist of Indian Institute of Chemical Biology (CSIR-IICB), Kolkata. He has joined IICB in 1972, retired from the institute as Director Grade Scientist on January, 2006 and was immediately invited by Heritage Institute of Technology, Kolkata (HITK) to join as Professor and Head, Department of Biotechnology. Since then, he is working as Professor, then as Dean (Post Graduate & Research) and retired on January, 2016. He was graduated with Hons. in chemistry (1964), Post graduated with Biochemistry (1966), and awarded D.Sc (1973), all under Calcutta University, India. He carried out Post-doctoral research at Herriot-Watt University, Edinburgh, UK (1981) and Osaka University, Osaka, Japan (1983). His research was focused in the area of antibiotics, enzyme technology, bioprocess development, therapeutic and commercial enzymes and glycosidase inhibitors of plant origins. He has R&D experience of 44 years at Indian Institute of Chemical Biology (CSIR), Kolkata and at HITK. He Acted as Adjunct Professor, Department of Biotechnology, Jadavpur University (1990–2000), Visiting Professor (2003–2006) and Full professor (2006–2016), HITK. He is the recipient of many prestigious awards. A few of them to mention: Silver Medal in M.Sc. Examination (2nd position) by Calcutta University (1966), Young Scientist Medal by Indian National Science Academy (1974) presented by the then Prime Minister Smt Indira Ghandhi, British Council – CSIR Exchange Program Fellowship (1980), Japan Academy of Science & INSA Exchange Program Fellowship (1984), Sankar Prasad Ghosh Memorial Award by the Department of Biochemistry, Calcutta University (1985), Prof. A. K. Chanda Memorial Award by the Department of Botany, Calcutta University (2003), 7th SR Bose Memorial Award, by Indian Mycological Society, 2007. He is a Fellow of West Bengal Academy of Science & Technology (FASc&T), Institute of Chemists India, (FIC). He has 17-Indian and 2-US patents in his name. He has published 117 journal papers, authored 17 book chapters and guided total 15 students for PhD He was Sectional President (New Biology): 90th Indian Science Congress Association (2002) and selected as Fellow, West Bengal Academy of Science & Technology and Institute of Chemists (India). He was also the associate editor of Journal of Indian Chemical Society (1991–93) and reviewer of many scientific journals.

Dr. Sudipta Dey Bandyopadhyay is currently an Assistant Professor at Department of Biotechnology, Heritage Institute of Technology, Kolkata. She obtained B.Tech in Chemical Engineering from Vidyasagar University, M.Tech in Biotechnology and Ph.D in Engineering from Jadavpur University, Kolkata. Her area of research includes bioprocess development, bioreactor design and scale up, modeling and simulation of bioprocess, downstream processing of biological products, environmental biotechnology, biological wastewater treatment and bioremediation of polycyclic aromatic hydrocarbons. She has research and teaching experience of total 15 years at Indian Institute of Chemical Biology, Jadavpur University and Heritage Institute of Technology, Kolkata. In addition to many conference publications (international and national), she has published many full papers in reputed peer reviewed international journals. Currently she is reviewer of

journals: Desalination and Water Treatment, Journal of Taiwan Institute of Chemical Engineers, Chemical Engineering Journal, International Journal of Environment and Waste Management, African Journal of Microbiology Research, International Journal of Emerging Technology & Advanced Engineering, Current Journal of Applied Science and Technology, Industrial & Engineering Chemistry Research. She is the life member of Indian Science Congress Association (ISCA) and life associate member of Indian Institute of Chemical Engineers (IIChE).

Dr. Avijit Ghosh is currently an Assistant Professor at Department of Chemical Engineering, Heritage Institute of Technology, Kolkata. He obtained B.Tech in Chemical Engineering from Heritage Institute of Technology, WBUT, M.Tech in Chemical Engineering from Calcutta University and Ph.D from Indian Institute of Technology, Guwahati, India. His major area of research includes Carbon nano-materials synthesis and characterization, polymer nano-composite for fuel cell application, fuel cells, noble metal free electrocatalyst, hydrogen production, hydrogen storage, solar cells, energy management. In addition to many international and national conference publications, he has published 12 full papers in peer reviewed journals. He has authored one book chapter (CRC press, Handbook of Graphene Science) and one monograph (Scholars' Press, Germany). He is member of the reviewer board of the Splendid Journals in the field of engineering and technology (2018) and editorial board member of International Journal of Nanomaterials and Nanostructures published by Journal Pub (2018). He is also reviewer of the Royal Society of Chemistry: RSC Advance. Recently, he has received Best Reviewer Award from International Journal of Hydrogen Energy (2017), Elsevier.



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Fungal Production of Single Cell Oil Using Defatted Oilseed Meals as Feedstock

Ruma Dutta, D. K. Bhattacharyya & Jayati Bhowal

Conference paper | First Online: 30 September 2020

Part of the Lecture Notes in Bioengineering book series (LNBE)

Abstract

In the present study, the production of single cell oil by three soil isolated strains of *Aspergillus* sp. was investigated in various basal lipid production media and by adding defatted oilseed (flaxseed, mustard, and rice bran) meal as supplements. Microorganisms were identified after screening from rice bran oil industry-drained soil, and their growth and lipid production rate were investigated in various fermentation media. The organisms were

incubated with various oilseed cakes for higher oleic acid (18:1) and linoleic acid (18:2) contents. Growth and lipid production were monitored for 10 days, in which the 7th day showed optimum results. An increase in lipid yield from 24 to 55% was observed when supplemented with defatted oilseed meals. The maximum lipid content was observed in potato dextrose medium when the microorganism was supplemented with 3% flaxseed meal for 7 days. Gas chromatography (GC) analysis showed that the major fatty acids produced were palmitic (16:0), palmitoleic (16:1), stearic (18:0), oleic (18:1), linoleic (18:2), and linolenic (18:3).

Keywords

Single cell oil **Meal supplements**

***Aspergillus* sp.** **Oleic acid** **Linoleic acid**