



Review

Sulfated Polysaccharides from Marine Algae as a Basis of Modern Biotechnologies for Creating Wound Dressings: Current Achievements and Future Prospects

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Abstract: Wound healing involves a complex cascade of cellular, molecular, and biochemical responses and signaling processes. It consists of successive interrelated phases, the duration of which depends on a multitude of factors. Wound treatment is a major healthcare issue that can be resolved by the development of effective and affordable wound dressings based on natural materials and biologically active substances. The proper use of modern wound dressings can significantly accelerate wound healing with minimum scar mark. Sulfated polysaccharides from seaweeds, with their unique structures and biological properties, as well as with a high potential to be used in various wound treatment methods, now undoubtedly play a major role in innovative biotechnologies of modern natural interactive dressings. These natural biopolymers are a novel and promising biologically active source for designing wound dressings based on alginates, fucoidans, carrageenans, and ulvans, which serve as active and effective therapeutic tools. The goal of this review is to summarize available information about the modern wound dressing technologies based on seaweed-derived polysaccharides, including those successfully implemented in commercial products, with a focus on promising and innovative designs. Future perspectives for the use of marine-derived biopolymers necessitate summarizing and analyzing results of numerous experiments and clinical trial data, developing a scientifically substantiated approach to wound treatment, and suggesting relevant practical recommendations.

Keywords: seaweed; sulfated polysaccharides; alginates; fucoidans; carrageenans; ulvans; wound dressing; wounds

1. Introduction

The skin is one of the most important organs which, besides protecting the body from external stresses and pathogenic microorganisms, is involved in respiration, thermoregulation, and communication with the environment via receptors. Each human is always exposed to all kinds of injuries and wounds while being at home, at work, or as a result of an accident. After being inflicted, they reduce the quality of life and, therefore, any skin damage must be immediately and effectively treated. The dynamic mechanism of wound healing is a process involving a complex cascade of

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Blue Biotechnology Stephane La Barre, Stephen S. Bates, 2018-12-10 With its integral treatment of ecosystem and resource management this is the only overview of the field to address current thinking and future trends All contributions have been written with the novice in mind explaining the basics and highlighting recent developments and achievements Unmatched in scope this two volume reference covers both traditional and well established areas of marine biotechnology such as biomass production alongside such novel ones as biofuels biological protection of structures and bioinspired materials In so doing it ties together information usually only found in widely dispersed sources to assemble a grand unified view of the current state of and prospects for this multi faceted discipline The combination of the breadth of topics and the focus on modern ideas make this introductory book especially suitable for teaching purposes and for guiding newcomers to the many possibilities offered by this booming field

Chemistry and Enzymology of Marine Algal Polysaccharides Elizabeth Percival, Richard H. McDowell, 1967

Marine Polysaccharides Volume 3 Paola Laurienzo (Ed.), 2018 The field of marine polysaccharides is constantly evolving due to progress in the discovery and production of new marine polysaccharides Seaweed remains the most abundant source of polysaccharides but recent advances in biotechnology have allowed the production of large quantities of polysaccharides from a variety of micro algae by controlling growth conditions and tailoring the production of bioactive compounds in a bioreactor Of particular interest are polysaccharides produced by micro organisms from extreme marine environments due to their recognized different biochemistry Extracellular polysaccharides EPSs with unique properties produced by a number of micro algae are known The first volume is a collection of papers concerning the identification and characterization of novel marine polysaccharides It is divided into three chapters the first two are dedicated to polysaccharides from different marine sources algae micro algae animals while the third one gathers information on the isolation characterization and bioactivity of new EPSs

Marine Polysaccharides Vazhiyil Venugopal, 2016-04-19 Increased public awareness of the importance of healthy living presents new challenges for the commercial food processing sector The industry is always on the hunt for novel and safe additives with functional properties that can be used to impart healthy and appealing properties to foods While the ocean is known as a conventional source of fish p

Marine Polysaccharides Volume 2 Paola Laurienzo (Ed.), 2018 The field of marine polysaccharides is constantly evolving due to progress in the discovery and production of new marine polysaccharides Seaweed remains the most abundant source of polysaccharides but recent advances in biotechnology have allowed the production of large quantities of polysaccharides from a variety of micro algae by controlling growth conditions and tailoring the production of bioactive compounds in a bioreactor Of particular interest are polysaccharides produced by micro organisms from extreme marine environments due to their recognized different biochemistry Extracellular polysaccharides EPSs with unique properties produced by a number of micro algae are known The first volume is a collection of papers concerning the identification and

characterization of novel marine polysaccharides It is divided into three chapters the first two are dedicated to polysaccharides from different marine sources algae micro algae animals while the third one gathers information on the isolation characterization and bioactivity of new EPSs **Marine Polysaccharides: An Applied Approach** Stephan Blackwood,2022-09-13 Polysaccharides are long polymeric chains of carbohydrates They are composed of monosaccharide units which are linked together by glycosidic linkages These biomolecules react with water to form constituent sugars Marine polysaccharides are carbohydrates of marine origin These are sulfated polysaccharides which are produced by concomitant fixation of sulphur and carbon Some common examples of marine polysaccharides are chitosan chitin carrageenan fucoidan and alginate These carbohydrates are gaining popularity as they have low extraction cost and are soluble in aqueous solution and extraction media Seaweeds and exoskeletons of crustaceans are some of the major resources of marine polysaccharides They find extensive application in the field of pharmaceuticals nutraceuticals cosmeceuticals and tissue engineering There has been rapid progress in this field and its applications are finding their way across multiple industries The various advancements in the study of marine polysaccharides are glanced at and their applications as well as ramifications are looked at in detail The topics covered in this book offer the readers new insights on marine polysaccharides

Functional Ingredients from Algae for Foods and Nutraceuticals Herminia Dominguez,2013-09-30 Algae have a long history of use as foods and for the production of food ingredients There is also increasing interest in their exploitation as sources of bioactive compounds for use in functional foods and nutraceuticals Functional ingredients from algae for foods and nutraceuticals reviews key topics in these areas encompassing both macroalgae seaweeds and microalgae After a chapter introducing the concept of algae as a source of biologically active ingredients for the formulation of functional foods and nutraceuticals part one explores the structure and occurrence of the major algal components Chapters discuss the chemical structures of algal polysaccharides algal lipids fatty acids and sterols algal proteins phlorotannins and pigments and minor compounds Part two highlights biological properties of algae and algal components and includes chapters on the antioxidant properties of algal components anticancer agents derived from marine algae anti obesity and anti diabetic activities of algae and algae and cardiovascular health Chapters in part three focus on the extraction of compounds and fractions from algae and cover conventional and alternative technologies for the production of algal polysaccharides Further chapters discuss enzymatic extraction subcritical water extraction and supercritical CO₂ extraction of bioactives from algae and ultrasonic and microwave assisted extraction and modification of algal components Finally chapters in part four explore applications of algae and algal components in foods functional foods and nutraceuticals including the design of healthier foods and beverages containing whole algae prebiotic properties of algae and algae supplemented products algal hydrocolloids for the production and delivery of probiotic bacteria and cosmeceuticals from algae Functional ingredients from algae for foods and nutraceuticals is a comprehensive resource for chemists chemical engineers and medical

researchers with an interest in algae and those in the algaculture food and nutraceutical industries interested in the commercialisation of products made from algae Provides an overview of the major compounds in algae considering both macroalgae seaweeds and microalgae Discusses methods for the extraction of bioactives from algae Describes the use of algae and products derived from them in the food and nutraceutical industries **Seaweed Polysaccharides** Jayachandran Venkatesan, Sukumaran Anil, Se-Kwon Kim, 2017-05-30 Seaweed Polysaccharides Isolation Biological and Biomedical Applications examines the isolation and characterization of algal biopolymers including a range of new biological and biomedical applications In recent years significant developments have been made in algae based polymers commonly called polysaccharides and in biomedical applications such as drug delivery wound dressings and tissue engineering Demand for algae based polymers is increasing and represent a potential very inexpensive resource for these applications The structure and chemical modification of algal polymers are covered as well as the biological properties of these materials including antithrombic anti inflammatory anticoagulant and antiviral aspects Toxicity of algal biopolymers is also covered Finally the book introduces and explains real world applications of algal based biopolymers in biomedical applications including tissue engineering drug delivery and biosensors This is the first book to cover the extraction techniques biomedical applications and the economic perspective of seaweed polysaccharides It is an essential text for researchers and industry professionals looking to work with this renewable resource Provides comprehensive coverage of the research currently taking place in biomedical applications of algae biopolymers Includes practical guidance on the isolation extraction and characterization of polysaccharides from sustainable marine sources Covers the extraction techniques biomedical applications and economic outlook of seaweed polysaccharides **Marine Polysaccharides** Paola Laurienzo, 2018 The field of marine polysaccharides is constantly evolving due to progress in the discovery and production of new marine polysaccharides Seaweed remains the most abundant source of polysaccharides but recent advances in biotechnology have allowed the production of large quantities of polysaccharides from a variety of micro algae by controlling growth conditions and tailoring the production of bioactive compounds in a bioreactor Of particular interest are polysaccharides produced by micro organisms from extreme marine environments due to their recognized different biochemistry Extracellular polysaccharides EPSs with unique properties produced by a number of micro algae are known The first volume is a collection of papers concerning the identification and characterization of novel marine polysaccharides It is divided into three chapters the first two are dedicated to polysaccharides from different marine sources algae micro algae animals while the third one gathers information on the isolation characterization and bioactivity of new EPSs **Marine Polysaccharides Volume 1** Paola Laurienzo (Ed.), 2018 The field of marine polysaccharides is constantly evolving due to progress in the discovery and production of new marine polysaccharides Seaweed remains the most abundant source of polysaccharides but recent advances in biotechnology have allowed the production of large quantities of polysaccharides from a variety of micro algae by

controlling growth conditions and tailoring the production of bioactive compounds in a bioreactor Of particular interest are polysaccharides produced by micro organisms from extreme marine environments due to their recognized different biochemistry Extracellular polysaccharides EPSs with unique properties produced by a number of micro algae are known The first volume is a collection of papers concerning the identification and characterization of novel marine polysaccharides It is divided into three chapters the first two are dedicated to polysaccharides from different marine sources algae micro algae animals while the third one gathers information on the isolation characterization and bioactivity of new EPSs

Enzymatic Technologies for Marine Polysaccharides Antonio Trincone, 2019-04-08 The bioactivity potential of marine polysaccharides has long been considered an underexploited aspect These molecules found in seaweed microalgae bacteria and animal fish shellfish mollusks etc and the derived oligosaccharides need to be explored thoroughly with an interdisciplinary approach They are an extraordinary source of chemical diversity and the literature highlights many applicative fields including the food industry cosmetics biomedicine agriculture environmental protection wastewater management etc More recently a new challenge has emerged the exploitation of marine biomass as the source of sustainable energy to participate in the future replacement of fossil resources Enzymatic Technologies for Marine Polysaccharides provides insight into the recent research developments of marine polysaccharides and their current and potential applications The first section of the book explores the diversity of marine polysaccharides from various angles including a description of the chemical complexity and current applications and new perspectives in food pharmaceutical cosmetics and biomaterials offered by recent research Efficient valorization of the marine polysaccharide biomass requires a rigorous analysis of the polysaccharides structure and their biological properties The second section of the book concerns the development of extraction techniques and the improvement of the methods aimed at the characterization of their structure and function Finally the third and last section of the book articulates the enzymatic technologies from the discovery of novel enzymes to their production pipelines related to the fields of biorefinery food pharmaceuticals and other fine chemicals Presents the latest research in marine oligosaccharides and polysaccharides Written by world class researchers in marine enzyme technology Discusses the latest developments in extraction methods Presents a detailed overview of enzymatic routes for modification production and synthesis of marine oligosaccharides Contains extensive references at the end of each chapter to enhance further study

Use of Colloidal Polysaccharides from Marine Algae in the Bread-baking Industry N. P. Kozmina, V. I. Baranova, 1968

A Study on the Water-soluble Polysaccharides of Marine Algae (Enteromorpha Sp.) 1960

Marine Polysaccharides Volume 3 Paola Laurienzo, 2018-04-24 This book is a printed edition of the Special Issue Marine Polysaccharides that was published in Marine Drugs

Marine Algae in Pharmaceutical Science. Vol. 1 Tore Levring, Yukio Tanaka, 2013-05-22 No detailed description available for MARINE ALGAE IN PHARMACEUTICAL SCIENCE VOL 1 E BOOK

Functional Ingredients from Algae for Foods and Nutraceuticals

Herminia Dominguez, 2017-11-13 Algae have a long history of use as foods and for the production of food ingredients. There is also increasing interest in their exploitation as sources of bioactive compounds for use in functional foods and nutraceuticals. Functional ingredients from algae for foods and nutraceuticals reviews key topics in these areas encompassing both macroalgae seaweeds and microalgae. After a chapter introducing the concept of algae as a source of biologically active ingredients for the formulation of functional foods and nutraceuticals, part one explores the structure and occurrence of the major algal components. Chapters discuss the chemical structures of algal polysaccharides, algal lipids, fatty acids, and sterols; algal proteins, phlorotannins, and pigments; and minor compounds. Part two highlights biological properties of algae and algal components and includes chapters on the antioxidant properties of algal components, anticancer agents derived from marine algae, anti-obesity and anti-diabetic activities of algae, and algae and cardiovascular health. Chapters in part three focus on the extraction of compounds and fractions from algae and cover conventional and alternative technologies for the production of algal polysaccharides. Further chapters discuss enzymatic extraction, subcritical water extraction, and supercritical CO₂ extraction of bioactives from algae, and ultrasonic and microwave assisted extraction and modification of algal components. Finally, chapters in part four explore applications of algae and algal components in foods, functional foods, and nutraceuticals, including the design of healthier foods and beverages containing whole algae, prebiotic properties of algae, and algae supplemented products, algal hydrocolloids for the production and delivery of probiotic bacteria, and cosmeceuticals from algae. Functional ingredients from algae for foods and nutraceuticals is a comprehensive resource for chemists, chemical engineers, and medical researchers with an interest in algae, and those in the algaculture, food, and nutraceutical industries interested in the commercialisation of products made from algae. Provides an overview of the major compounds in algae, considering both macroalgae seaweeds and microalgae. Discusses methods for the extraction of bioactives from algae. Describes the use of algae and products derived from them in the food and nutraceutical industries. *BIOTECH MARINE POLYSACCHARIDES* Rita R. Colwell, Ernst R. Pariser, Anthony J. Sinskey, 1985 **Extraction, Characterization and Biological Effects of Polysaccharides from Marine (micro)algae**, 2022 Polysaccharide Utilization by Bacteria Associated with Micro- and Macroalgae Fengqing Wang, 2024 Algae play a crucial role in marine carbon cycling. This involves various polysaccharides of different functions to which algae convert a significant proportion of their photoassimilated organic carbon. Suitable conditions provided microalgae phytoplankton can proliferate very fast. During such blooms, substantial quantities of dissolved and particulate polysaccharide-rich organic matter are released to the environment, both by exudation of living and by decomposition of dead algal cells. While research on the community and functional dynamics of free-living bacteria during phytoplankton blooms is extensive, knowledge about particle-attached bacteria, especially regarding taxonomic composition and associated gene functions, is limited. Like planktonic microalgae, sessile macroalgae are also rich in polysaccharides and harbor bacteria with significant potential for polysaccharide degradation, particularly for

complex polysaccharides However research on macroalgal phycosphere microbes so far primarily focused on community composition studies via 16S rRNA gene amplicon sequencing and meta genomic analysis of single algal species or a limited number of samples This thesis provides a comprehensive exploration of microalgae associated microbial communities during phytoplankton blooms and of macroalgae associated phycosphere communities both with a focus on polysaccharide utilization functions Chapter I establishes the theoretical foundation of this thesis It starts out with a review of the critical roles that micro and macroalgae play within the marine carbon budgets It then narrows down to explore phytoplankton blooms key events in marine carbon cycling marked by rapid carbon fixation remineralization and release The studies of marine particles are summarized Afterwards common polysaccharides of micro and macroalgae are introduced as well as the mechanisms of bacterial polysaccharide utilization Then research methodologies in microbial ecology are outlined with a focus on the analysis of omics data which form the core methodologies in the two subsequent chapters and finally the chapter closes with a summary of the research questions that this thesis aims to address In Chapter II I present a study in which I explored dynamic shifts in community composition and polysaccharide degradation functions of particle attached bacteria throughout an extensive phytoplankton bloom in contrast to those of free living bacteria Bloom progression was captured using microscopic chlorophyll a and 18S rRNA gene amplicon data at high temporal resolution I identified abundant bacterial clades using corresponding high resolution 16S rRNA gene amplicon sequencing across three filter size fractions during the bloom Through metagenome data analysis using both short and long read sequencing I then identified and explored abundant polysaccharide degrading bacteria Additionally metaproteome data were analyzed to correlate bacterial proteins with the breakdown of algal glycans The combined results indicated that similar to their free living counterparts particle attached polysaccharide degrading bacteria targeted soluble and structurally simple polysaccharides such as laminarin However they also possessed abundant genes dedicated to the degradation of insoluble and structurally complex polysaccharides setting them apart in their functional capabilities As detailed in Chapter III I had a major part in analyzing the composition and polysaccharide utilization functions of macroalgal phycosphere bacteria on four types of macroalgae across the four seasons Comparisons were made with microbial communities in surrounding seawater and sediment revealing fourteen core genera consistently present on all algae Metagenome analysis focused on polysaccharide degradation and secondary metabolite production while cultivation techniques yielded pure isolates for draft genome sequencing A high cultivability of macroalgal phycosphere bacteria enabled sequencing of numerous isolates offering insights into a manifold of polysaccharide utilization loci and their possible polysaccharide substrates Chapter IV presents a comparative analysis of particle attached bacteria originating from microalgae versus those from macroalgal phycospheres a pioneering endeavor not previously undertaken This way I identified dominant bacteria shared between both studied communities alongside unique clades specific to each community Furthermore the advantages of utilizing PacBio metagenome sequencing drafting genome

sequences of cultivable strains and the application of multiple databases for functional annotation are discussed including insights to enhance the study of particle attached bacteria and isolated strains The thesis then closes with an outlook with a proposal for future projects

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Table of Contents Polysaccharides Producing Marine Algae Pdf Wordpress

1. Understanding the eBook Polysaccharides Producing Marine Algae Pdf Wordpress
 - The Rise of Digital Reading Polysaccharides Producing Marine Algae Pdf Wordpress
 - Advantages of eBooks Over Traditional Books
2. Identifying Polysaccharides Producing Marine Algae Pdf Wordpress
 - Exploring Different Genres
 - Considering Fiction vs. Non-Fiction
 - Determining Your Reading Goals
3. Choosing the Right eBook Platform
 - Popular eBook Platforms
 - Features to Look for in an Polysaccharides Producing Marine Algae Pdf Wordpress
 - User-Friendly Interface
4. Exploring eBook Recommendations from Polysaccharides Producing Marine Algae Pdf Wordpress
 - Personalized Recommendations
 - Polysaccharides Producing Marine Algae Pdf Wordpress User Reviews and Ratings
 - Polysaccharides Producing Marine Algae Pdf Wordpress and Bestseller Lists
5. Accessing Polysaccharides Producing Marine Algae Pdf Wordpress Free and Paid eBooks
 - Polysaccharides Producing Marine Algae Pdf Wordpress Public Domain eBooks
 - Polysaccharides Producing Marine Algae Pdf Wordpress eBook Subscription Services
 - Polysaccharides Producing Marine Algae Pdf Wordpress Budget-Friendly Options
6. Navigating Polysaccharides Producing Marine Algae Pdf Wordpress eBook Formats

- ePub, PDF, MOBI, and More
 - Polysaccharides Producing Marine Algae Pdf Wordpress Compatibility with Devices
 - Polysaccharides Producing Marine Algae Pdf Wordpress Enhanced eBook Features
7. Enhancing Your Reading Experience
 - Adjustable Fonts and Text Sizes of Polysaccharides Producing Marine Algae Pdf Wordpress
 - Highlighting and Note-Taking Polysaccharides Producing Marine Algae Pdf Wordpress
 - Interactive Elements Polysaccharides Producing Marine Algae Pdf Wordpress
 8. Staying Engaged with Polysaccharides Producing Marine Algae Pdf Wordpress
 - Joining Online Reading Communities
 - Participating in Virtual Book Clubs
 - Following Authors and Publishers Polysaccharides Producing Marine Algae Pdf Wordpress
 9. Balancing eBooks and Physical Books Polysaccharides Producing Marine Algae Pdf Wordpress
 - Benefits of a Digital Library
 - Creating a Diverse Reading Collection Polysaccharides Producing Marine Algae Pdf Wordpress
 10. Overcoming Reading Challenges
 - Dealing with Digital Eye Strain
 - Minimizing Distractions
 - Managing Screen Time
 11. Cultivating a Reading Routine Polysaccharides Producing Marine Algae Pdf Wordpress
 - Setting Reading Goals Polysaccharides Producing Marine Algae Pdf Wordpress
 - Carving Out Dedicated Reading Time
 12. Sourcing Reliable Information of Polysaccharides Producing Marine Algae Pdf Wordpress
 - Fact-Checking eBook Content of Polysaccharides Producing Marine Algae Pdf Wordpress
 - Distinguishing Credible Sources
 13. Promoting Lifelong Learning
 - Utilizing eBooks for Skill Development
 - Exploring Educational eBooks
 14. Embracing eBook Trends
 - Integration of Multimedia Elements
 - Interactive and Gamified eBooks

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