ejpmr, 2025, 12(4), 248-255

SJIF Impact Factor 7.065

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Review Article

ISSN 2394-3211

EJPMR

A COMPREHENSIVE REVIEW ON MARINE PHARMACOGNOSY

Drisya M. K.* and Nowfa Firoskhan

India.

***Corresponding Author: Drisya M. K.**

India.

Article Received on 09/02/2025 **Article Revised on 29/02/2025** **Article Published on 19/03/2025**

ABSTRACT

Marine Pharmacognosy is the study of bioactive compounds derived from marine organisms and their potential applications in medicine, biotechnology and related fields. It focuses on exploring the chemical diversity of marine ecosystems, including microorganisms, algae, sponges and marine invertebrates, to discover novel natural products with therapeutic properties. This field also investigates the ecological roles of these metabolites, such as defense mechanism or signaling molecules, to better understand their potential applications. The purpose of this review is to provide a comprehensive analysis and synthesis of the current state of knowledge in this field.

KEYWORDS: Marine pharmacognosy, bioactive compounds, marine drugs, challenges.

INTRODUCTION

INTRODUCTION TO MARINE PHARMACOGNOSY

Marine pharmacognosy is a specialized branch of pharmacognosy that focuses on the study of biologically active compounds derived from marine organisms. Covering a wide array of life forms including marine bacteria, fungi, algae, sponges, corals, mollusks, and other invertebrates this field explores the unique chemical diversity of the marine environment as a source of novel natural products. The marine ecosystem, which covers over 70% of the Earth's surface, is a largely untapped reservoir of biodiversity. Marine organisms have evolved unique metabolic pathways to survive under extreme conditions such as high pressure, low temperatures, limited light, and high salinity. These adaptations often result in the production of secondary metabolites with highly complex and unique structures, many of which exhibit potent biological activities. Marine Pharmacognosy holds immense potential for discovering novel bioactive compounds with therapeutic and industrial applications. The present review aims to provide the detailed description of marine pharmacognosy.

HISTORY

The history of Marine Pharmacognosy reflect the evolving understanding and exploration of marine natural products over centuries. Its development can be traced through distinct phases, beginning with ancient knowledge of marine resources and progressing to the modern era of sophisticated drug discovery.

Ancient civilization including the Egyptians, Greeks and Chinese recognized the therapeutic potential of marine resources. Marine algae, sponges and shellfish were used in traditional medicine for their healing and nutritional properties. The systematic study of marine organisms began during the age of exploration (18th -19th century) when naturalist collected and catalogued marine specimens. In the late 19th century scientist began isolating bioactive compounds from marine sources, such as brominated compounds from sponges. The 1950's marked the beginning of modern marine pharmacognosy (mid -20th century) driven be advancements in chemical extraction and analytical techniques. By the 1970's & 1980's (late 20th century) marine natural product research expanded, fueled by the discovery of more pote t bioactive metabolites. Marine pharmacognosy today (current era-21st century) integrate cutting edge tehnologies such as genomics, metabolomics and synthetic biology.

The history of Marine pharmacognosy highlights its significant contributions to drug discovery and biomedical research with ongoing advancements in technology and increased focus on marine biodiversity conservation, the field is poised to make even greater strides in developing life-saving therapies.

SCOPE OF MARINE PHARMACOGNOSY

Marine pharmacognosy is an interdisciplinary field that encompasses the discovery, characterization, and application of bioactive compounds from marine organisms. Its scope is broad, touching upon diverse scientific disciplines, technological advancements, and therapeutic applications. The key areas of focus include:

1. Drug Discovery and Development
Marine organisms are a rich source of structurally unique secondary metabolites with potent biological activities. The scope includes:

- *Cancer therapy*: Discovery of anti-cancer agents like trabectedin and dolastatin-10.
- *Antiviral and antimicrobial agents*: Development of new treatments for infections and emerging diseases.
- *Pain management*: Compounds such as ziconotide derived from cone snail venom.
- *Neuroprotective agents*: Exploring compounds for treating neurodegenerative disorders like Alzheimer's and Parkinson's diseases.

2. Chemical Diversity and Structural Innovation
Marine organisms produce highly diverse and complex natural products, often with unique chemical scaffolds not found in terrestrial sources. The scope includes:

- Elucidation of novel chemical structures.
- Development of synthetic analogs and derivatives for enhanced efficacy and reduced toxicity.

3. Marine Microbiology and Biotechnology
Marine microorganisms, such as bacteria, fungi, and cyanobacteria, are a key focus for their ability to produce bioactive metabolites. Applications include:

- Industrial-scale production of bioactive compounds using microbial fermentation.
- Genetic engineering and synthetic biology to optimize compound yields.

4. Environmental and Ecological Studies
Understanding the ecological roles of marine natural products, such as defense mechanisms or chemical signaling, provides insights for:

- Developing eco-friendly antifouling agents for marine industries.
- Discovering bioinspired materials and compounds.

5. Sustainable Resource Management
Given the challenges of overexploitation and environmental impact, the scope of marine pharmacognosy includes:

- Developing sustainable harvesting practices for marine organisms.
- Using aquaculture and mariculture to grow marine species for research and production.
- Leveraging chemical synthesis and biotechnological approaches to reduce dependence on natural populations.

6. Interdisciplinary Research and Collaboration
Marine pharmacognosy integrates diverse fields such as:

- *Marine biology*: Understanding marine biodiversity.
- *Organic chemistry*: Structural characterization of marine metabolites.
- *Pharmacology*: Evaluating biological activities and mechanisms of action.
- *Biotechnology*: Scaling up production of valuable compounds.

7. Therapeutic and Non-Therapeutic Applications

- *Nutraceuticals*: Marine-derived functional foods and supplements for health promotion.
- *Cosmeceuticals*: Bioactive compounds for skincare and anti-aging products.
- *Agriculture*: Natural pesticides and plant growth enhancers from marine sources.

KEY ASPECTS OF MARINE PHARMACOGNOSY
Sources of Bioactive compound in marine pharmacognosy, bioactive compounds are derived from a variety of marine organisms. These compounds exhibit diverse pharmacological properties, including anticancer, antimicrobial, antiviral, and anti-inflammatory effects. Below are the main sources of bioactive compounds:

1. Marine Microorganisms

1. *Bacteria*: Marine bacteria, including Streptomyces and Salinispora, produce antibiotics (e.g., salinosporamide A) and anticancer agents.
2. *Fungi*: Marine-derived fungi like Penicillium and Aspergillus are sources of secondary metabolites with antibacterial and antifungal properties.
3. *Actinomycetes*: These produce polyketides and peptides with antimicrobial and anticancer activity.

2. Marine Algae
Macroalgae (Seaweeds)

- Red, green, and brown algae produce polysaccharides, carotenoids, and phenolic compounds with antioxidant, antiviral, and anti-inflammatory properties.

Examples
Fucoidan from brown algae (Laminaria), carrageenan from red algae.

Microalgae

- Species like Spirulina and Chlorella produce omega-3 fatty acids, pigments, and bioactive peptides.

3. Marine Invertebrates

- *Sponges*: Rich in alkaloids, terpenoids, and polyketides with anticancer, antiviral, and antifungal activities (e.g., cytarabine for leukemia treatment).
- *Corals and Gorgonians*: Produce terpenoids and steroids with anti-inflammatory and antitumor properties.
- *Tunicates (Sea Squirts)*: Source of the anticancer drug trabectedin (Yondelis).
- *Mollusks*: Secrete bioactive peptides and toxins with analgesic and neuroprotective properties.

4. Marine Vertebrates
- *Fish*: Produce bioactive peptides, collagen, and omega-3 fatty acids beneficial for cardiovascular health.
- *Sharks*: Shark liver oil contains squalene with antioxidant and immune-boosting effects.

5. Marine Plants (Seagrasses and Mangroves)
- *Seagrasses:* produce phenolic compounds and flavonoids with antioxidant and anti-inflammatory properties.
- *Mangroves*: source of tannins, saponins, and triterpenoids with antimicrobial activity.

6. Marine Cyanobacteria (Blue-Green Algae)
Produce toxins like microcystins and bioactive compounds with anticancer, antiviral, and anti-inflammatory activities.

7. Marine Animals (Cnidarians and Echinoderms)
- *Jellyfish and Sea Anemones*: Contain bioactive peptides and neurotoxins with potential therapeutic applications.
- *Starfish and Sea Cucumbers*: Produce triterpene glycosides and sulfated polysaccharides with anticancer and anticoagulant effects.

TYPES OF BIOACTIVE COMPOUNDS
Marine pharmacognosy has revealed a wide range of bioactive compounds with unique chemical structures and pharmacological properties. These compounds, often secondary metabolites, are classified based on their chemical nature and biological activities. Below are the main types of bioactive compounds found in marine pharmacognosy:

1. Alkaloids
Definition: Nitrogen-containing organic compounds with diverse biological activities.
Examples
- Fascaplysin (from sponges): Anticancer activity.
- Topsentin (from sponges): Anti-inflammatory and antifungal effects.
- Ecteinascidin 743 (trabectedin): Anticancer drug derived from tunicates.

2. Polyketides
Definition: A large family of natural products produced by polyketide synthases, often with antibiotic and anticancer properties.
Examples
- Salinosporamide A (from Salinispora bacteria): Anticancer activity.
- Discodermolide (from sponges): Antitumor agent.
- Bryostatins (from bryozoans): Anticancer and immunomodulatory properties.

3. Peptides
Definition: Short chains of amino acids with diverse therapeutic applications.
Examples
- Kahalalide F (from mollusks and algae): Anticancer and antiviral activity.
- Conotoxins (from cone snails): Potent neurotoxins used as painkillers.

4. Terpenoids
Definition: Large class of organic compounds derived from isoprene units, often with antimicrobial and anti-inflammatory properties.
Examples
- Pseudopterosins (from gorgonians): Anti-inflammatory and analgesic effects.
- Siphonarin (from sponges): Antiviral properties.

5. Sterols and Steroids
Definition: Organic compounds with a sterane backbone, known for their anti-inflammatory and cytotoxic activities.
Examples
- Fucosterol (from brown algae): Antioxidant and anticancer effects.
- Cholestanol derivatives (from sponges): Antitumor activity.

6. Sulfated Polysaccharides
Definition: Complex carbohydrates with sulfate groups, exhibiting antiviral, anticoagulant, and immunomodulatory properties.
Examples
- Fucoidan (from brown algae): Antiviral, anticoagulant, and anticancer effects.
- Carrageenan (from red algae): Antiviral and anti-inflammatory activity.

7. Lipids and Fatty Acids
Definition: Organic compounds including omega-3 and omega-6 fatty acids with cardiovascular and anti-inflammatory benefits.
Examples
- Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) from fish oils.
- Squalene (from sharks): Antioxidant and immune-boosting effects.

8. Quinones and Hydroquinones
Definition: Aromatic compounds with redox properties, often with antibacterial and anticancer activities.
Examples
- Aplysinaquinone (from sponges): Antibacterial and cytotoxic effects.
- Plakortin (from marine sponges): Antimalarial activity.

9. Cyanobacterial Toxins
Definition: Toxic compounds produced by marine cyanobacteria with potential therapeutic applications at low doses.

Examples
- Microcystins: Anticancer activity.
- Curacin A: Anticancer and antitumor properties

10. Phenolic Compounds
Definition: Compounds containing one or more phenol groups, known for their antioxidant and anti-inflammatory properties.
Examples
- Phlorotannins (from brown algae): Antioxidant and anti-diabetic activity.

11. Toxins and Venoms
Definition: Bioactive molecules from venomous marine animals with potential as painkillers and neuroprotective agents.
Examples
- Tetrodotoxin (from pufferfish): Neurotoxin with potential analgesic properties.
- Zoanthoxanthins (from sea anemones): Antiviral and anticancer activities.

MARINE -DERIVED COMPOUNDS
Several drugs have been developed from marine-derived compounds, showcasing the potential of marine pharmacognosy in medicine. Here are some notable examples:
1. Cytarabine (Ara-C)
Source: Marine sponge (Cryptotheca crypta).
Uses: Treatment of leukemia (e.g., acute myeloid leukemia) and lymphoma.
Mechanism: Inhibits DNA synthesis by acting as a nucleoside analog.

2. Trabectedin (Yondelis)
Source: Sea squirt (Ecteinascidia turbinate).
Uses: Soft tissue sarcomas and ovarian cancer.
Mechanism: Binds to DNA and disrupts transcription, leading to cell death.

3. Ziconotide (Prialt)
Source: Cone snail (Conus magus).
Uses: Severe chronic pain (non-opioid alternative).
Mechanism: Blocks calcium channels in nerve cells, reducing pain signaling.

4. Brentuximab Vedotin (Adcetris)
Source: Dolastatin 10, a compound derived from sea hare (Dolabella auricularia).
Uses: Hodgkin lymphoma and anaplastic large cell lymphoma.
Mechanism: An antibody-drug conjugate that delivers cytotoxic agents to cancer cells.

5. Eribulin (Halaven)
Source: Marine sponge (Halichondria okadai).
Uses: Metastatic breast cancer and liposarcoma.
Mechanism: Inhibits microtubule dynamics, leading to cancer cell apoptosis.

6. Vidarabine (Ara-A)
Source: Marine sponge (Cryptotheca crypta).
Uses: Antiviral agent for herpes simplex and varicella-zoster infections.
Mechanism: Inhibits viral DNA polymerase.

7. Plitidepsin (Aplidin)
Source: Sea squirt (Aplidium albicans).
Uses: Multiple myeloma and being explored for COVID-19 treatment.
Mechanism: Inhibits eEF1A (eukaryotic elongation factor), disrupting protein synthesis in cancer cells.

8. Omega-3 Fatty Acids
Source: Marine fish oils and microalgae.
Uses: Cardiovascular health, reducing triglycerides, and anti-inflammatory effects.
Mechanism: Modulates lipid metabolism and reduces inflammation.

9. Squalamine
Source: Dogfish shark liver.
Uses: Potential anti-cancer, anti-angiogenic, and antimicrobial applications.
Mechanism: Inhibits angiogenesis and bacterial growth.

10. Tetrodotoxin (TTX)
Source: Pufferfish and other marine species.
Uses: Investigated for pain relief, particularly in cancer-related pain.
Mechanism: Blocks sodium channels, preventing nerve conduction.

APPLICATIONS
Marine pharmacognosy has broad applications in medicine, biotechnology, and industry due to the diverse and unique bioactive compounds derived from marine organisms. Below are the primary applications of marine pharmacognosy:

1. Pharmaceutical Applications
Marine-derived compounds have shown significant potential for the development of new drugs for various diseases:

a. Cancer Treatment
- *Trabectedin (Yondelis):* Derived from the tunicate Ecteinascidia turbinate, used for soft tissue sarcoma and ovarian cancer.
- *Bryostatin-1:* From bryozoans, studied for anticancer and neuroprotective effects.
- *Halichondrin B*: From sponges, the basis for the anticancer drug eribulin.

b. Antibiotics and Antimicrobials
- *Marinopyrrole*: From marine bacteria, shows antibacterial activity against resistant pathogens.
- *Salinosporamide* A: From Salinispora bacteria, has anticancer and antibacterial properties.

c. Antiviral Drugs
- *Avarol*: From sponges, shows antiviral activity against HIV.
- *Carrageenan*: From red algae, used as an antiviral agent in topical formulations.

d. Anti-inflammatory Agents
- *Pseudopterosins*: From gorgonians, exhibit potent anti-inflammatory and analgesic properties.

e. Neurological Disorders
- *Ziconotide (Prialt):* Derived from cone snail venom, used to treat severe chronic pain.

2. Nutraceuticals and Dietary Supplements

Marine bioactive compounds are used in health supplements due to their nutritional and therapeutic benefits:
- *Omega-3 Fatty Acids*: Found in fish oils, beneficial for heart and brain health.
- *Fucoidan*: From brown algae, used for its immune-boosting and anti-cancer properties.
- *Astaxanthin*: From microalgae, a powerful antioxidant used in anti-aging and eye health supplements.

3. Cosmeceuticals

Marine-derived compounds are widely used in skincare and cosmetic products for their anti-aging, moisturizing, and skin-repairing properties:
- *Collagen*: Extracted from fish and other marine sources, used in anti-aging creams.
- *Alginate*: From brown algae, used as a thickener and moisturizer in cosmetics.
- *Squalene*: From sharks and plant-based marine sources, used in skin hydration products.

4. Biotechnology and Industrial Applications
- *Enzymes*:Marine enzymes, such as proteases and lipases, are used in industrial processes like food production, detergents, and biofuel generation.
- *Bioplastics*: Marine polysaccharides, like chitin and alginate, are used to create biodegradable plastics.
- *Biofilms and Adhesives*: Compounds from mussels and barnacles are used to develop medical adhesives and antifouling coatings.

5. Agricultural Applications
- *Pesticides*: Marine-derived compounds such as kahalalide F have been studied for their pesticidal properties.
- *Fertilizers*: Seaweed extracts are used as organic fertilizers to enhance plant growth and resistance to stress.

6. Environmental Applications
- *Bioremediation*: Marine microorganisms and algae are used to clean up oil spills and remove heavy metals from polluted waters.
- *Antifouling Agents*: Compounds from marine organisms are used to prevent the accumulation of biofouling on ships and underwater structures.

7. Veterinary Medicine
- Marine pharmacognosy contributes to veterinary health by providing bioactive compounds for treating diseases in animals. For example:
- Algal extracts are used in feed supplements to improve livestock health.

8. Research and Drug Discovery
- Marine pharmacognosy continues to drive innovation in drug discovery:
- It provides new chemical scaffolds for synthetic biology and medicinal chemistry.
- High-throughput screening of marine compounds accelerates the development of novel drugs.

CHALLENGES AND OPPURTUNITIES

Marine pharmacognosy holds immense potential for discovering novel bioactive compounds with therapeutic and industrial applications. However, it faces several challenges alongside promising opportunities. Here's a detailed breakdown:

Challenges in Marine Pharmacognosy

1. Resource Accessibility and Collection
- *Limited Access*: Many bioactive compounds are derived from deep-sea organisms, requiring advanced technology for exploration and collection.
- *Environmental Concerns*: Overharvesting marine resources can harm delicate ecosystems and biodiversity.
- *Seasonal and Geographical Variation*: The chemical composition of marine organisms may vary based on location, depth, and season, complicating standardization.

2. Complexity of Bioactive Compounds
- *Structural Complexity*: Marine compounds often have intricate and novel structures, making them challenging to synthesize or modify.
- *Low Yield:* Many marine organisms produce bioactive compounds in very small quantities, limiting their immediate use in large-scale applications.

3. Sustainability Issues
- *Overexploitation*: Harvesting large quantities of marine organisms for bioactive compounds risks endangering species and disrupting ecosystems.
- *Difficulty in Cultivation*: Some marine organisms are difficult to culture in laboratory settings, limiting sustainable production.

4. Technological and Financial Constraints

- *High Costs*: Exploration, extraction, and characterization of marine compounds require costly equipment and technology.
- *Need for Advanced Techniques*: Specialized tools such as remotely operated vehicles (ROVs) and metagenomics are essential but expensive.
- *Funding Limitations*: Research in marine pharmacognosy often struggles to secure sufficient funding due to its high-risk, high-reward nature.

5. Regulatory and Ethical Issues

- *Intellectual Property Rights (IPR):* Conflicts over the ownership of marine genetic resources can delay research and commercialization.
- *Legal Frameworks:* International regulations, like the Nagoya Protocol, complicate access to marine genetic resources and sharing of benefits.

6. Slow Drug Development Process

- *Long Timeframes*: The transition from compound discovery to marketable drug can take decades.
- *High Attrition Rates*: Many compounds show promising activity in early stages but faduring preclinical or clinical trials.

OPPORTUNITIES IN MARINE PHARMACOGNOSY

1. Drug Discovery and Development

- Marine organisms provide a vast, largely untapped reservoir of unique chemical entities, offering potential for developing new drugs to treat cancer, infections, inflammation, and neurological disorders.
- Success stories like trabectedin (anticancer) and ziconotide (pain relief) highlight the field promise.

2. Advancements in Technology

- *Metagenomics and Genomics*: Enable the identification of bioactive compounds from unculturable marine microbes.
- *Synthetic Biology*: Allows for the production of complex marine-derived compounds in laboratory settings, reducing reliance on natural sources.
- *High-Throughput Screening*: Speeds up the identification of promising bioactive compounds.

3. Sustainable Cultivation Techniques

- *Marine Aquaculture*: Cultivating marine organisms (e.g., sponges, algae) for bioactive compound production reduces environmental impact and ensures a steady supply.
- *Fermentation and Bioreactor Systems*: Enable large-scale production of marine-derivedcompounds using microbial hosts.

4. Cosmeceutical and Nutraceutical Markets

- Growing demand for natural and sustainable products creates opportunities for marine-derived compounds in cosmetics and dietary supplements.
- Compounds like astaxanthin (antioxidant) and collagen (anti-aging) are increasingly popular.

5. Collaborative Research Initiatives

- *Public-Private Partnerships*: Collaboration between academic institutions, governments, and pharmaceutical companies can accelerate research and development.
- *Global Biodiversity Programs*: Initiatives like the Census of Marine Life help discover and document new marine species with potential bioactive compounds.

6. Biotechnology and Industrial Applications

- Marine-derived enzymes and polymers (e.g., chitin, alginate) are valuable in industries like food processing, biofuels, and bioplastics.
- Development of antifouling agents, adhesives, and bioremediation technologies offers lucrative opportunities.

7. Addressing Unmet Medical Needs

- Increasing antibiotic resistance and the need for novel anticancer agents drive interest in marine pharmacognosy.
- Marine bioactive compounds could address gaps in the treatment of rare or neglected diseases.

RESEARCH AND DEVELOPMENT

Research and development (R&D) in marine pharmacognosy focus on exploring marine biodiversity to discover, isolate, and develop bioactive compounds with potential pharmaceutical, nutraceutical, and industrial applications. The R&D process involves multidisciplinary approaches combining marine biology, chemistry, pharmacology, and biotechnology.

1. Bioprospecting Marine Organisms

Objective: Identify marine organisms (e.g., sponges, algae, fungi, bacteria, and invertebrates)that produce bioactive secondary metabolites.

Approach

- Conduct exploratory missions in diverse marine environments such as deep seas, coral reefs, and hydrothermal vents.
- Use advanced tools like remotely operated vehicles (ROVs) for sampling in extreme environments.

Examples

- Sponges have been a rich source of anticancer and antiviral compounds like halichondrin B and avarol.
- Cyanobacteria yield compounds like curacin A, an anticancer agent.

2. Isolation and Characterization of Bioactive Compounds

Techniques

- Extraction using solvents to isolate bioactive metabolites.
- Structural elucidation through methods like NMR, mass spectrometry, and X-ray crystallography.

Goal:

- Identify the structure and biological activity of novel compounds for therapeutic use.

3. Screening for Biological Activity

- *High-Throughput Screening (HTS)*: Rapidly tests thousands of marine-derived compounds for biological activity against specific disease targets.
- *In vitro and In vivo Models*: Evaluate antimicrobial, anticancer, anti-inflammatory, and other pharmacological properties.

Case Study

- Trabectedin, derived from tunicates, was developed for its potent anticancer activity through rigorous screening and evaluation.

4. Drug Development and Preclinical Studies

- *Preclinical Testing*: Assess toxicity, pharmacokinetics, and efficacy of marine-derived compounds in animal models.
- *Lead Optimization*: Modify the structure of bioactive compounds to enhance efficacy, reduce toxicity, and improve drug-like properties.

Example:

- Ziconotide, a pain-relief drug, was developed from cone snail venom after extensive preclinical research.

5. Biotechnology and Synthetic Biology

- *Marine Microbial Cultivation*: Develop methods to culture marine microorganisms for sustainable production of bioactive compounds.
- *Genetic Engineering*: Use synthetic biology to express marine genes in host organisms (e.g., bacteria, yeast) for large-scale compound production.

Example

- Production of salinosporamide A, a marine-derived anticancer compound, through fermentation of Salinispora bacteria.

6. Metabolomics and Genomics

- *Metabolomics*: Study the metabolic profiles of marine organisms to identify novel secondary metabolites.
- Genomics and Metagenomics: Explore the genetic potential of marine organisms and their symbionts for producing bioactive compounds.

Example

- Discovery of biosynthetic gene clusters in sponges and their microbial symbionts has led to the identification of new drug candidates.

7. Formulation and Drug Delivery Systems

- Develop advanced drug delivery systems (e.g., nanoparticles, liposomes) for effective delivery of marine-derived drugs.
- Optimize formulations for improved stability, bioavailability, and targeted therapy.
- Collaborative and Interdisciplinary Efforts
- Academic-Industry Partnerships: Foster collaboration between research institutions and pharmaceutical companies to translate discoveries into marketable products.

CONCLUSION

Marine pharmacognosy is a rapidly growing field with diverse applications in healthcare, cosmetics, agriculture and industry. By harnessing the unique properties of marine bioactive compounds, researchers aim to address global challenges in medicine and sustainable development. The scope of marine pharmacognosy is vast and continuously expanding, driven by technological advancements and the growing need for novel therapeutic agents. With the untapped potential of marine biodiversity and interdisciplinary research efforts, this field holds great promise for addressing global health challenges and fostering endurable innovation. By addressing current challenges and leveraging technological advancements, marine pharmacognosy holds the potential to revolutionize drug discovery and contribute significantly to global health and resilience. The vast diversity of marine life provides a rich and largely untapped reservoir of bioactive compounds. Research in marine pharmacognosy continues to explore and optimize the use of these natural products for therapeutic and industrial applications.

REFERENCE

1. Blunt, J. W., Copp, B. R., Keyzers, R. A., Munro, M. H. G., & Prinsep, M. R. Marine natural products. Natural Product Reports, 2018; 35(1): 8-53.
2. Newman, D. J., & Cragg, G. M. Natural Products as Sources of New Drugs from 1981 to 2014. Journal of Natural Products, 2016; 79(3): 629–661.
3. Mayer, A. M. S., et al. Marine Pharmacology in 2005–2006: Marine Compounds with Antibacterial, Anticoagulant, Antifungal, Anti-inflammatory, Antiparasitic, and Antiviral Activities; Affecting the Cardiovascular, Endocrine, Immune, and Nervous Systems, and Other Miscellaneous Mechanisms of Action. Marine Drugs, 2010; 8(3): 536-579.
4. Jimens J, Fairdoth G, Fernandez Sousa-Faro JM, Schever P and Rinehart K, New marine derived anticancer therapeutics- A Journal from the sea to clinical trials, Mar Drugs, 2004; 2: 14-29
5. Alejandno MS, Mayer, Kirk.R. Gustafson: Marine Pharmacology in 2005-2006: Antitumor and cytotoxic compounds, EJC, 2008; 44: 2357-2387.
6. Thakur NL, Thakur AN, Muller WEG: Marine natural products in drug discovery, Natural Product Radiance, 2005; 4(6): 471-477.

7. Munro MHG, The discovery and development of marine compounds with pharmaceutical potential, J Biotechnol, 1999; 70: 15-25.
8. Blunt, J. W., Copp, B. R., Keyzers, R. A., Munro, M. H. and Prinsep, M. R. Marine natural products. Nat. Prod. Rep., 2016; 33: 382-43.
9. Bergmann W, Feeney RJ Contributions to the study of marine products. XXXII. The nucleosides of sponges. I. J Org Chem., 1951; 16(6): 981–987.
10. Yosri N, et al. Marine organisms: pioneer natural sources of polysaccharides/proteins for green synthesis of nanoparticles and their potential applications. Int J Biol Macromol, 2021; 193: 1767–98.
11. Lu W-Y, Li H-J, Li Q-Y, Wu Y-C. Application of marine natural products in drug research. Bioorg Med Chem., 2021; 35: 116058.
12. Carroll AR, Copp BR, Davis RA, Keyzers RA, Prinsep MR. Marine natural products. Nat Prod Rep., 2023; 40: 275–325.
13. Khalifa SAM, et al. Marine natural products: a source of novel anticancer drugs. Mar Drugs, 2019; 17: 491.
14. Altmann K-H. Drugs from the oceans: marine natural products as leads for drug discovery. Chimia, 2017; 71: 646.
15. Hamed I, Ozogul F, Özogul Y, Regenstein J. Marine bioactive compounds and their health benefits: a review. Compr Rev Food Sci Food Saf., 2015; 14(4).
16. Liang X, Luo D, Luesch H. Advances in exploring the therapeutic potential of marine natural products. Pharmacol Res., 2019; 147: 104373.
17. El Gamal AA. Biological importance of marine algae. Saudi Pharm J., 2010; 18(1): 1–25.
18. Tan LT. Bioactive natural products from marine cyanobacteria for drug discovery. Phytochemistry, 2007; 68: 954–79.
19. Carte BK. Biomedical potential of marine natural products. Bioscience, 1996; 46: 271–86.