TPM Vol. 32, No. S6, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

MARINE NATURAL PRODUCTS AS ANTIOXIDANT AGENTS

ABROR KHAMRAEV
TASHKENT MEDICAL ACADEMY, UZBEKISTAN, EMAIL: khamraev.abror@gmail.com
ORCID ID: HTTPS://ORCID.ORG/0000-0001-5242-5148

UMAROVA NIGORAKHON KHOLMATOVNA
FACULTY OF LINGUISTICS, TURAN INTERNATIONAL UNIVERSITY, NAMANGAN,
EMAIL: uzbekistan.maftuna9917@gmail.com, HTTPS://ORCID.ORG/0009-0009-8243-3718

ZAID AJZAN BALASSEM
DEPARTMENT OF COMPUTERS TECHNIQUES ENGINEERING, COLLEGE OF TECHNICAL ENGINEERING, ISLAMIC UNIVERSITY OF NAJAF, NAJAF, IRAQ
DEPARTMENT OF COMPUTERS TECHNIQUES ENGINEERING, COLLEGE OF TECHNICAL ENGINEERING, ISLAMIC UNIVERSITY OF NAJAF OF AL DIWANIYAH, AL DIWANIYAH, IRAQ
EMAIL: Eng.Iu.Comp.Zaidsalami12@Gmail.Com

PANDIAN MAHADEVAN
DEPARTMENT OF NAUTICAL SCIENCE, AMET UNIVERSITY, KANATHUR, TAMILNADU -603112,
EMAIL: pandian.mahadevan@ametuniv.ac.in, 0009-0005-5067-5625

DR. PRIYAMBADA SINGH
ASSISTANT PROFESSOR, DEPARTMENT OF MICROBIOLOGY, KALINGA UNIVERSITY, RAIPUR, INDIA.

Abstract
Interest in studying marine-biota-derived, biologically active chemicals as potential antibiotic, antiaging, antiviral, and anticancer substitutes has been sparked by their well-known but understudied antioxidant activity. In order to generate some suggestions for next industrial applications, the current review aims to provide an overview of the most recent developments in the field of antioxidants produced from marine biota. Techniques: The various varieties of antioxidant compounds, contemporary derivation biotechnologies, and marine sources of natural antioxidants have all been reviewed and updated throughout the past five years. Findings: In addition to new antioxidant molecules and derivation techniques, new marine sources of antioxidants, such as wastes and byproducts, are examined. Conclusions: There is still a need for valuable antioxidants from marine biota. Because microorganisms are becoming more resistant to antibiotics, natural substances with both antioxidant and antimicrobial properties are of interest. In addition to antioxidant chemicals isolated from marine life that have been previously identified, new ones are discovered. Waste and byproducts are excellent places to find antioxidant chemicals for identification.
Keywords: natural antioxidants, marine sources, antioxidant substances

1. INTRODUCTION

Marine organisms and their metabolites are the focus of international efforts to discover novel, physiologically active compounds that are recognized as the cornerstone of the future bioeconomy, particularly of possible pharmaceuticals. Rare, structurally diverse compounds produced by marine organisms can occasionally exhibit higher levels of biological activity compared to those originating from terrestrial sources [1]. The marine biota produces secondary metabolites and macromolecules with well-known antioxidant qualities as a result of defense mechanisms it develops in response to environmental stressors and variations[2]. The need for compounds with both antibacterial and antioxidant properties in a single molecule is increased by the growth of chronic disorders, which are frequently connected to the colonization of drug-resistant organisms[10].
Although numerous studies have documented the antioxidant activity of extracts, fractions, synergistic mixtures, and individual compounds in vitro and in vivo, the search for marine sources, broad-spectrum agents with antioxidant activity, and novel properties that are relevant to a range of industries remains ongoing[4]. Non-traditional optimum derivation is expected to yield sustainable alternative methods for preserving the potency of derived antioxidant compounds, in addition to numerous other advantages. This review aims to present current

natural marine antioxidant products as promising candidates for future industrial applications by updating the literature spanning the last five years on marine sources of natural antioxidant compounds, different classes of antioxidant compounds, current derivation biotechnologies, and characterization methodologies[6].

Free radicals cause nucleic acid disruption, cellular function disintegration, and enzyme denaturation and peroxidation of lipids in cellular membranes[8]. Oxidative stress has been used to describe all of these problems [3]. The equilibrium between the production of reactive oxygen species (ROS) and antioxidant defense activity is upset by oxidative stress. Overproduction of ROS can damage various cell components, resulting in aging-related tissue damage and a host of chronic illnesses, such as diabetes, cancer, heart disease, neurological disorders, and many more. The generation of ROS can be significantly reduced by natural antioxidants[9].

2. REVIEW OF LITERATURE

Any material that inhibits a free radical reaction to stop oxidation is an antioxidant. By balancing out the excess of these chemicals in the body, antioxidants in biological systems reduce the negative consequences of metabolic processes, including highly reactive free radicals[11]. The two main categories of antioxidant defense systems are enzymatic and non-enzymatic. Ascorbate peroxidase, glutathione reductase, catalase, and superoxide dismutase are examples of enzymatic antioxidants[12]. Organic compounds such vitamins, polysaccharides, polyphenols, peptides, and others make up non-enzymic antioxidants. Marine antioxidants that are biodegradable and non-toxic may be used to prevent cancer, autoimmune illnesses, aging, and some degenerative diseases, as well as to lessen oxidative stress brought on by free radicals in food storage and cosmetics. [15].

The marine species, extraction and purification techniques, and operating circumstances all affect antioxidant capacity. Because this also depends on the climate conditions that support marine biota, antioxidant agents of the same species have varying compositions around the world.The second stage is to isolate, purify, and identify naturally occurring chemicals that have antioxidant action[14]. In some cases, the replication of natural antioxidant molecules by chemical synthesis is the next step. Most marine creatures that produce antioxidants have already been identified, and many more are still to be found[16]. Recently, there has been a noticeable increase in the conversion of marine biota trash and byproducts into resources[18].

Seaweeds have been the focus of the most research since they are believed to be the most prevalent source of strong antioxidants in the marine environment. The nutritional value, aesthetic appeal, and therapeutic potential of marine macroalgae are covered in a large number of review and research papers. Improved marine algae production techniques are anticipated as a result of multidisciplinary scientific approaches, including physiological, molecular, chemical, technical, and technological ones. Chains of short or long amino acids with different molecular weights and structures make up peptides[5]. Usually made up of residues between amino acids, bioactive peptides show activity as soon as they are released from the parent protein. Their industrial manufacture is hampered by a number of issues, including low-yield bioactivity and high production costs. New technologies like microwaves, high pressure, pulsed electric fields, and others are said to solve issues with traditional hydrolysis techniques like chemical, enzymatic, and fermentation procedures.

3. MATERIALS AND METHOD

According to chemical analysis and the MS spectra of the fractionated and purified crude methanol extract made by freeze-thawing, the antioxidant fraction from the marine bacteria K. marina CDMP is made up of short-chain peptides. Human cells may be shielded from chemically induced oxidative stress by these small, non-cytotoxic peptide compounds. Given its demonstrated capacity for scavenging free radicals against hepatocellular carcinoma cell lines, Ser–Ser–Gln peptide may be a promising pharmaceutical option with antioxidant action. Up to 60% of the soluble cellular proteins in microalgae are made up of the three water-soluble phycobilin proteins: phycoerythrin, phycocyanin, and allophycocyanin. Their strong antioxidant and free radical scavenging properties are well known. Research into improved extraction methods is still ongoing because of their substantial commercial potential as natural pigments in nutraceutical, cosmetic, and medical uses[13].

Fucoidans and carrageenan are brown, green, and red algal sulfated polysaccharides that are believed qualities variances. Compared to food-grade antioxidants like butylated alcohol, sulfated polysaccharides, which are present in macroalgal cell walls, are more effective at scavenging nitric oxide. The source of the algae from which the sulfated polysaccharides are extracted, as well as their molecular weight, degree of sulfation, chemical structure, primary sugar content, and glycosidic branching, all affect their antioxidant efficacy.Low-molecular-weight sulfated polysaccharides are known to be more powerful antioxidants than high-molecular-weight sulfated polysaccharides because they can enter cells and contribute protons more efficiently. As potential substitutes for the synthetic compounds and antioxidants already in use, a range of marine pigments are currently being investigated.

The most prevalent class of natural pigments that give marine life its stunning hues and antioxidant qualities are called carotenoids. Carotenoids, being tetraterpenes, are classified into two chemical classes: Lycopene, α-, and β-carotene are examples of carotenes, which are composed of hydrogen and carbon, whereas lutein, astaxanthin, and fucoxanthin are examples of xanthophylls, which are composed of hydrogen, carbon, and oxygen. All autotrophic marine species, including bacteria, fungi, algae, and archaea, as well as certain other organisms, create carotenoids, which are lipophilic compounds. According to their mode and extent of action, the carotenoids: (i) quench singlet molecular oxygen; (ii) break down hydroperoxides by forming more stable derivatives; (iii) stop auto-oxidation chain reactions and free radical oxidation reactions to prevent the production of free radicals; and (iv) chelate (convert into non-toxic molecules). Derivatives of iron and copper. Apart from their use in pigmentation, they also hold great medical potential for immune system stimulation and the prevention of neurological diseases.Due to several advantages over chemical or terrestrial plant alternatives, such as cost, time, and yield, biotechnological production of natural marine carotenoids has increased significantly [7]. By shielding the bilayer lipid structure from peroxidation, exogenously supplied antioxidants lutein, astaxanthin, and α- and β-carotene scavenge free radicals and prevent oxidative damage. Because of its unique chemical structure, which combines polar ionic rings and apolar conjugated carbon–carbon bonds, astaxanthin has an antioxidant potential that is roughly 10 times higher than that of other carotenoids (lutein, canthaxanthin, and β-carotene). Nanoencapsulation is being explored as a means to enhance the physiochemical characteristics and health-promoting advantages of carotenoids while maintaining their natural attributes during processing and storage.

4. RESULT AND DISCUSSION

Ovothiols are histidine thiol derivatives that, depending on where the thiol group is located on the imidazole ring of the histidine, have unique anti-proliferative, anti-fibrotic, and antioxidant properties. Sulfoxide synthase OvoA and sulfoxide lyase OvoB are the enzymes that create ovothiols. Marine pathogenic protozoa, microalgae, invertebrates, and mollusks were shown to have three different ovothiol types with different levels of methylation in their ovaries, eggs, and biological fluids. Natural polyphenolic antioxidants are better in this regard because synthetic phenolic antioxidants (SPAs) are commonly used in many commercial and industrial products to prolong product lifespans and slow down oxidative processes[17].

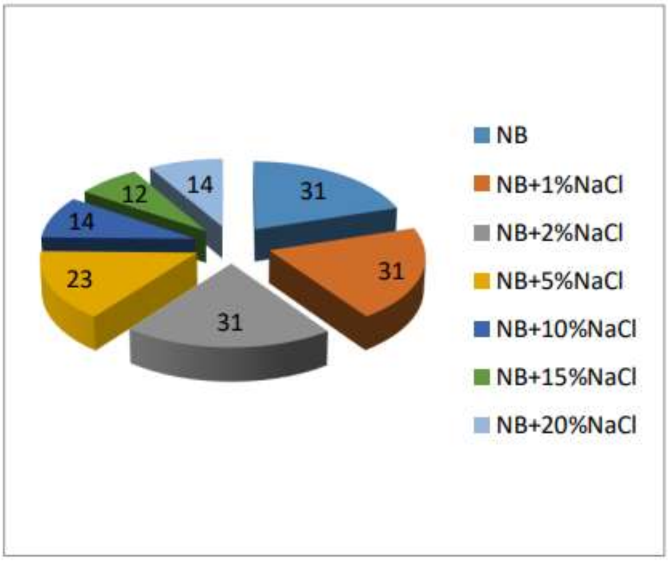

Figure 1: Graphical representation

Among the different components, solvents play a significant part in the extraction's effectiveness. Safe, high-quality components can be extracted while maintaining the biological activity of the extracted molecules using the right solvent. Because it can be recycled and used again, it doesn't harm the environment. The target family of chemicals can be extracted selectively thanks to the wide range of solvents with different polarities. The polarity and chemical structure of the materials to be extracted determine which solvent is best; compounds with different chemical structures require different polarity solvents. Carotenoids, for example, are lipid-soluble antioxidants that are extracted using organic solvent systems such as ethyl acetate with acetone, ethanol, or methanol blends or hexane with acetone, ethanol, or methanol blends. Most of the antioxidant chemicals found in phenols are hydro-soluble.

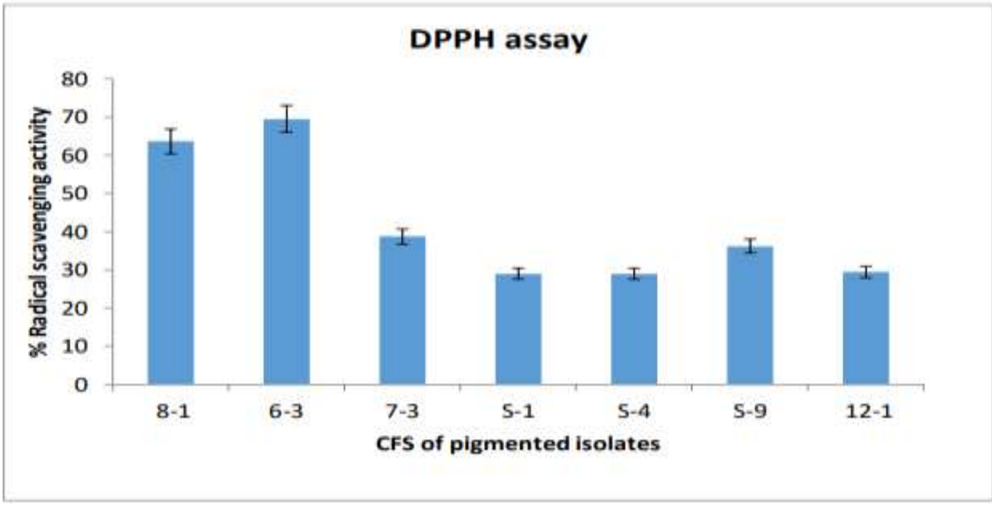

Figure 2: DPPH assay

Pulsed electric fields (PEF) and moderate electric fields (MEF), which target the cellular permeabilization of microalgae and the subsequent release of valuable components, are expected to become standard techniques that could soon be used on an industrial scale for microalgae exploitation, according to recent studies in the basic field. Because of their high energy efficiency and minimal use of non-renewable resources, electrotechnologies—which depend on the direct application of an external electric field through a semi-conductive medium—are one of the numerous biotechnological processes that are both cost-effective and environmentally friendly. When compared to traditional techniques, the new technologies are distinguished by shorter extraction times and lower solvent requirements.

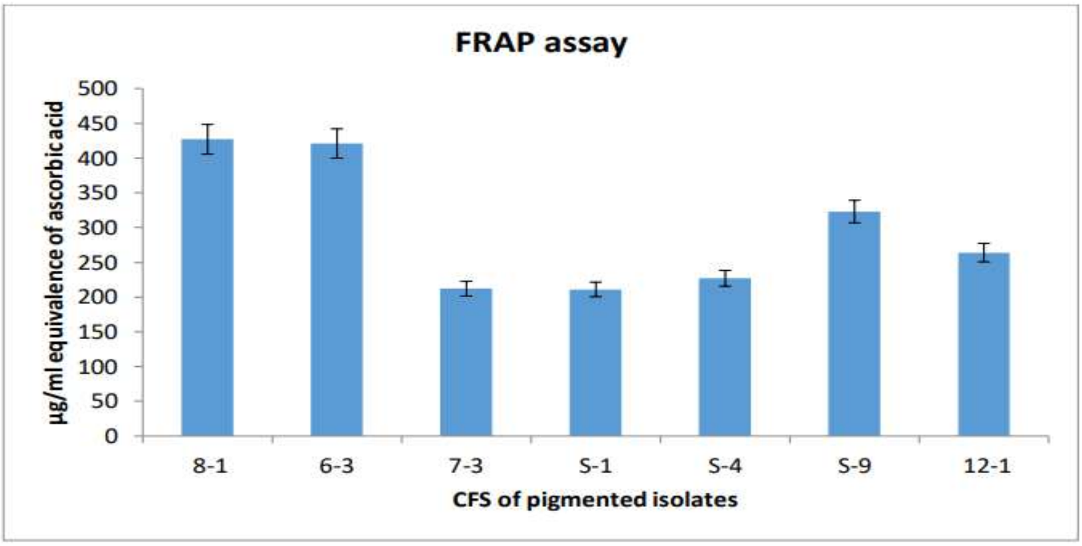

Figure 3: FRAP assay

Information regarding the pharmacological properties and biological effects of recently created antioxidant compounds would be useful for treating infections, cancer, antibiotic resistance, and other human diseases. For future industrial production, the ability to obtain safe products with significant added value is especially crucial.

5. CONCLUSION

Over the past few years, there has been a continued need for beneficial antioxidant chemicals that come from marine sources. Natural compounds that possess both antioxidant and antibacterial activity in a single molecule are currently of great interest due to the growing prevalence of microbial antibiotic and multidrug resistance. New natural marine antioxidant sources, antioxidant metabolites, antioxidant characteristics, and medicinal and other applications have been discovered. Trash and leftovers provide a wealth of compounds with antioxidant qualities in addition to a wide variety of marine life. The quality of the necessary components can be improved and production intensified thanks to new derivation techniques and enhanced extraction procedures. Non-traditional derivation technologies, including subcritical water extraction, microwave, or ultrasound, are better than conventional extraction methods because of their effectiveness, the activity of the active ingredient, and environmental preservation. Evaluation of the possible problems and their implementation in real-world applications should thus be the main goals of future study. Identifying the most promising organisms, extracts, or compounds is challenging because their significance extends beyond their contents to include a complicated set of attributes that are important for a variety of applications, the function of the derived biotechnology, and the operating conditions.

REFERENCES

1 Aqil, Farrukh, Maryam Zahin, Khalid A. El Sayed, Iqbal Ahmad, Khaled Y. Orabi, and Jamal M. Arif. "Antimicrobial, antioxidant, and antimutagenic activities of selected marine natural products and tobacco cembranoids." *Drug and chemical toxicology* 34, no. 2 (2011): 167-179.
2 Fu, W., & Zhang, Y. (2025). The role of embedded systems in the development of smart cities: A review. SCCTS Journal of Embedded Systems Design and Applications, 2(2), 65–71.
3 Park, Eun-Jung, and John M. Pezzuto. "Antioxidant marine products in cancer chemoprevention." Antioxidants & redox signaling 19, no. 2 (2013): 115-138.
4 Marie Johanne, Andreas Magnus, Ingrid Sofie, & Henrik Alexander (2025). IoT-based smart grid systems: New advancement on wireless sensor network integration. Journal of Wireless Sensor Networks and IoT, 2(2), 1-10.
5 Shahidi, F., and Y. Zhong. "Antioxidants from marine by-products." In Maximising the value of marine by-products, pp. 397-412. Woodhead Publishing, 2007.
6 Carlos, A., José, D., & Antonio, J. A. (2025). Structural health monitoring and impact in civil engineering. Innovative Reviews in Engineering and Science, 3(1), 1–8. https://doi.org/10.31838/INES/03.01.01
7 Balakrishnan, Dhivya, Dhevendran Kandasamy, and Paramasivam Nithyanand. "A review on antioxidant activity of marine organisms." Int. J. Chem. Tech. Res 6, no. 7 (2014): 3431-3436.
8 Frincke, G., & Wang, X. (2025). Hardware/software co-design advances for optimizing resource allocation in reconfigurable systems. SCCTS Transactions on Reconfigurable Computing, 2(2), 15–24.
9 Sethi, K., & Kapoor, M. (2024). Data-Driven Marketing in the Age of AI: Reflections from the Periodic Series on Technology and Business Integration. In Digital Marketing Innovations (pp. 7-11). Periodic Series in Multidisciplinary Studies.
10 Shinde, Pravin, Paromita Banerjee, and Anita Mandhare. "Marine natural products as source of new drugs: A patent review (2015–2018)." Expert opinion on therapeutic patents 29, no. 4 (2019): 283-309.
11 Erdoğan, M. A., & Demir, F. N. (2025). FPGA hardware-software co-design for real-time embedded systems (M. A. Erdoğan & F. N. Demir, Trans.). Journal of Integrated VLSI, Embedded and Computing Technologies, 2(2), 1–8. https://doi.org/10.31838/JIVCT/02.02.01
12 Dutta, R., &Alam, T. (2024). Policy Harmonization for SDG Implementation in the ASEAN Region: Challenges and Opportunities. International Journal of SDG's Prospects and Breakthroughs, 2(3), 4-6.
13 Khalifa, Shaden AM, Nizar Elias, Mohamed A. Farag, Lei Chen, Aamer Saeed, Mohamed-Elamir F. Hegazy, Moustafa S. Moustafa et al. "Marine natural products: A source of novel anticancer drugs." Marine drugs 17, no. 9 (2019): 491.
14 Rahim, R. (2023). Effective 60 GHz signal propagation in complex indoor settings. National Journal of RF Engineering and Wireless Communication, 1(1), 23-29. https://doi.org/10.31838/RFMW/01.01.03
15 Gogineni, Vedanjali, Raymond F. Schinazi, and Mark T. Hamann. "Role of marine natural products in the genesis of antiviral agents." Chemical reviews 115, no. 18 (2015): 9655-9706.
16 Zorpette, G., Sengur, A., & Urban, J. E. (2023). Technological improvements in green technology and their consequences. International Journal of Communication and Computer Technologies, 11(2), 1-6. https://doi.org/10.31838/IJCCTS/11.02.01
17 Takamatsu, Satoshi, Tyler W. Hodges, Ira Rajbhandari, William H. Gerwick, Mark T. Hamann, and Dale G. Nagle. "Marine natural products as novel antioxidant prototypes." Journal of natural products 66, no. 5 (2003): 605-608.
18 Natheem, J., Rajkumar, S., Thaniyeal, P., Thavanish, P., & Suganya, S. (2023). Fake News Detection using Naive Bayes Algorithm in Machine Learning. International Journal of Advances in Engineering and Emerging Technology, 14(1), 93–102
19 Maria, E., Sofia, K., & Georgios, K. (2025). Reliable data delivery in large-scale IoT networks using hybrid routing protocols. Journal of Wireless Sensor Networks and IoT, 2(1), 69-75.

20 Sampedro, R., & Wang, K. (2025). Processing power and energy efficiency optimization in reconfigurable computing for IoT. SCCTS Transactions on Reconfigurable Computing, 2(2), 31–37. https://doi.org/10.31838/RCC/02.02.05
21 McCorkindale, W., & Ghahramani, R. (2025). Machine learning in chemical engineering for future trends and recent applications. Innovative Reviews in Engineering and Science, 3(2), 1–12. https://doi.org/10.31838/INES/03.02.01
22 Salameh, A. A., & Mohamed, O. (2024). Design and Performance Analysis of Adiabatic Logic Circuits Using FinFET Technology. Journal of VLSI Circuits and Systems, 6(2), 84–90. https://doi.org/10.31838/jvcs/06.02.09
23 Vishnupriya, T. (2025). Wireless body area network (WBAN) antenna design with SAR analysis. National Journal of RF Circuits and Wireless Systems, 2(1), 37–43.
24 Prasath, C. A. (2025). Adaptive filtering techniques for real-time audio signal enhancement in noisy environments. National Journal of Signal and Image Processing, 1(1), 26–33.
25 ELIZA, A., PURNAMASARI, F., & VERAWATI, H. (2025). Does Covid-19 Pandemic Boost the Financial Performance of Zakat Management Organization in Indonesia?. Quality-Access to Success, 26(206).