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

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PHARMACOLOGICAL POTENTIAL OF MARINE ALGAE: A REVIEW

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Abstract
Microalgae, which include dinoflagellates, diatoms, and cyanobacteria, are unicellular, nearly microscopic organisms. In terms of organic production via photosynthesis, they are the main producers in the oceanic food web. Due to their multicellular nature, seaweeds and macroalgae occur on a macroscopic scale. In addition, seaweeds create extensive sub-marine forest habitats that provide refuge and food for marine life. Sargassum, Gracillariids, and kelps (Macrocystis, Laminaria) are a few examples. The high carbohydrate and bioactive content of the corresponding phylum has led to the commercial harvesting of macroalgae for use in food and medicinal manufacturing. Aquaculture can also benefit greatly from the use of marine algae. Microalgae are a common food source for fish, prawns, and bivalves that are crucial to the long-term viability of the aquaculture industry. Certain species are employed to improve larval eating, which raises the hatchery larvae's survival rate.
Keywords: Microalgae, Marine microalgae, Marine algae, anticancer compounds.

1. INTRODUCTION

Both marine macroalgae and microalgae are environmentally benign and can be extracted as abundant sources of bioactive compounds that may find use in industry and biomedicine to restore the properties of cells, tissues, or microorganisms [1]. Depending on the amount of these components, which are regulated by biotic (plant and microbe) and abiotic (salinity, pH, temperature, and illumination) variables, these bioactive molecules include proteins, carbohydrates, minerals, fatty acids, antioxidants, and pigments. Furthermore, by focusing on anticancer-associated molecular targets linked to the development of cancer, pigments, lipids, and carotenoids synthesized from microalgae have been shown to have anticancer properties in several cell lines[10]. Inhibiting viral replication, these SPs and other secondary metabolites may be promising therapeutic agents for viral infections[8]. Generally speaking, brown algae have strong anti-biofilm properties such as phlorotannin, fatty acids and lipids (γ-linolenic acid and linoleic acid), carotenoids (zeaxanthin and lutein), and sulphated polysaccharides (fucoidan). Furthermore, it has been demonstrated that alkaloids and flavonoids derived from algae selectively disrupt important cellular functions as invasion, migration, and the cell cycle[2]. Particularly, ulva extracts have shown remarkable anticancer action; research suggests that they may inhibit tumor growth in both live things and laboratory conditions [3][11]. Notwithstanding their advantages, toxic algal blooms provide risks to the environment and the economy, underscoring the significance of efficient environmental management[4]. Furthermore, the distribution of algae is influenced by topography, which results in hotspots for biodiversity in various marine domains. To use marine algae responsibly, more research into their use in the food, medicine, and energy industries as well as their preservation is necessary. Understanding the functional diversity, environmental importance, and economic potential of marine algae will ensure both ecological stability and appropriate use[6]. To maximize the potential of these marine algae in the best possible way, future research must concentrate on improving culture techniques, producing more novel bioactive chemicals, and lessening the detrimental effects of toxic blooms[9].

2. REVIEW OF LITERATURE

Filling these gaps bridged by biotechnological advances, nano-formulation approaches, and gap mechanistic studies are expected to have a central function in integrating marine algae bio actives into oncology therapy of the future. Moving marine algal metabolite-based antiviral and anticancer therapeutic solutions from the lab bench to the bedside will be primarily driven by the need to comprehend structure–activity correlations (SARs) and optimize delivery mechanisms for bioactive chemicals[12]. New pharmaceuticals can be found in marine algae, which provide a natural and renewable source of antiviral and anticancer medications[14]. To fully realize the immense potential of these substances of marine origin in human medical practice, future study on the frontier of this field would require interdisciplinary interactions between marine biology, pharmacology, and clinical sciences[14].
It is especially vital in preventing corrosion of metal parts whose corrosion might result in substantial financial losses in a variety of industries [5]. In the food sector, they are well-known as a high-density, protein-rich food product that contains vitamins, minerals, and essential elements that can help avoid diseases like chronic obesity and cardiovascular disorders[16]. The bulk of traditional algal food products are beneficial to human health and nutrition because they are rich in n-3 fatty acids, vital amino acids, and dietary fibers. But due to the very high bioactive compound diversity of marine algae, their extraction and actual applications are still a great deal of challenge[18].

3. MATERIALS AND METHODS

Marine algae are either micro- or macro-sized unicellular autotrophs that are found in the ocean. While macroalgae, also known as seaweeds, are multicellular and comprise green, brown, and red algae, microalgae, such as diatoms, dinoflagellates, and cyanobacteria (blue-green algae), are unicellular. Due to their unicell composition, cyanobacteria, diatoms, and dinoflagellates are classified as microalgae. As the fundamental living organisms of underwater ecosystems, they also play a key role in underwater oxygenation and biodiversity and have a wide range of industrial uses. They are divided into two major groups: microalgae and macroalgae, and they inhabit maritime environments. Marine algae are useful in the food, medicinal, and biofuel industries in addition to their ecological significance[17]. But they also serve as significant repositories of blue carbon sequestration, which helps slow down global warming. They need to be categorized, bioactive compounds identified, and geographical and environmental distribution determined in order to be utilized and conserved sustainably [13].
Surveillance and mitigation measures are necessary because these locations are particularly vulnerable to the increasing prevalence of HABs. However, the main grazers of temperate coastal settings, particularly in Southeast Australia and the Northeast Pacific, are macroalgae such as kelps and fucoid seaweeds. These macroalgal groupings flourish in environments with consistent temperatures and sufficient light penetration. Additionally, they reduce erosion, create crucial habitats for fish and invertebrates, and are crucial for marine biodiversity and coastal preservation. According to estimates, up to 20.8 million km2 of sea area can be farmed with marine algae. This gives an idea of the potential scale and industrialization of the macroalgae farming sector. The increased production of seaweed for cultivation could further involve marine algae in the global economy by ensuring food security, carbon sequestration, and renewable biofuels[7].

4. RESULT AND DISCUSSION

Particularly as anti-inflammatory, antioxidant, and antibacterial chemicals, marine algae exhibit promise as possible bioactive substances to be employed in the development of therapeutic interventions [15].

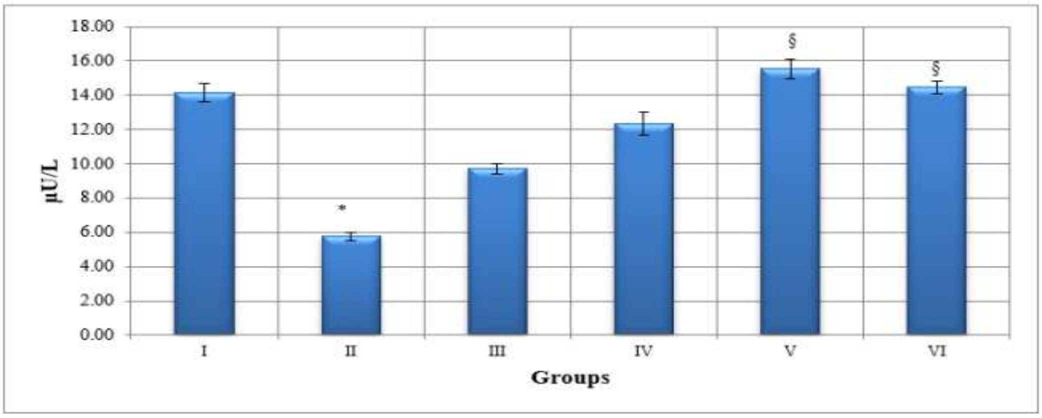

Figure 1: Effect of MAPA

Polyphenols, carotenoids, and bromophenols are examples of secondary metabolites from micro- and macroalgas that have biological properties such as antibacterial, anticancer, and antioxidant properties. Marine algae show promises as raw material to synthesize pharmaceutical medicine, biomedical products, nutraceuticals, and cosmeceuticals. These metabolites may consist of pigments, terpenoids, antioxidants, carotenoids, polyunsaturated fatty acids (PUFAs), tocopherol, polysaccharides, e.g., amino acids.

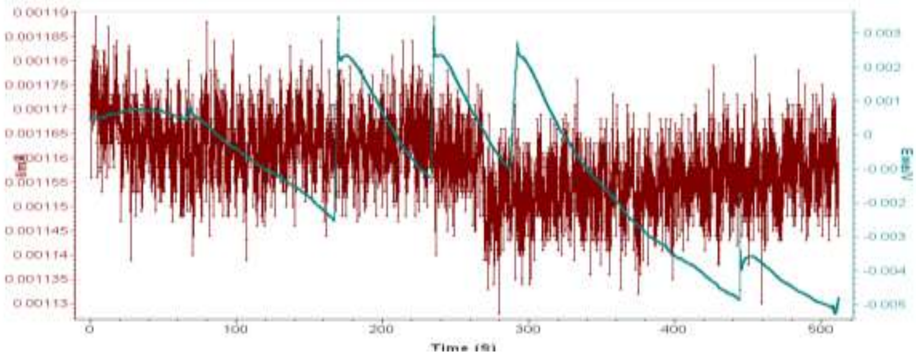

Figure 2: Potential and current response of MS

For instance, it has been demonstrated that carotenoids isolated from several algae species and phlorotannin from brown algae can modify oxidative stress and inflammatory processes. Sulfated polysaccharides (SPs), particularly those obtained from marine algae, are easily obtained and have a wide range of medicinal uses, including anticoagulant, antiviral, anticancer, and antioxidant properties. Recent research has shown that microalgae have anticancer properties, with extracts showing a potent anti-proliferative effect on a variety of cancer cell types.

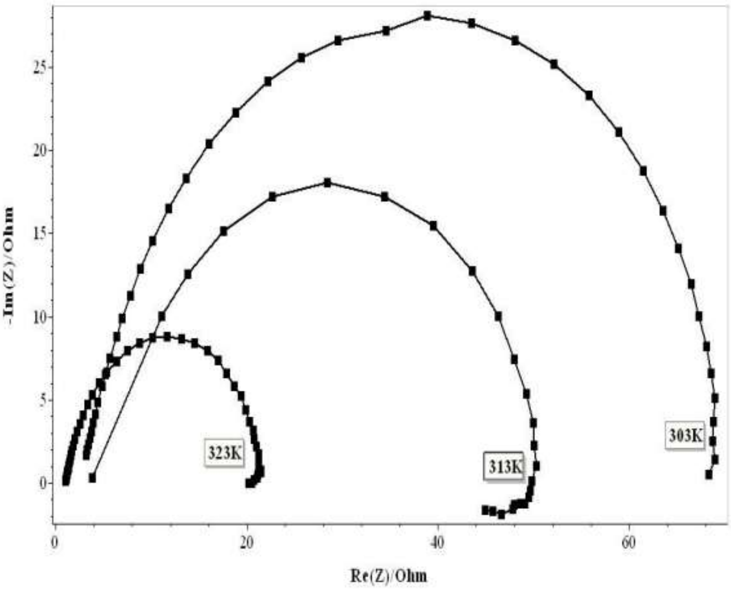

Figure 3: Nyquist plots

They decrease cell survival and death by blocking the PI3K/Akt (phosphoinositide 3-kinase/protein kinase B) pathway. Additionally, it has been discovered that fucoidans inhibit the activation of NF (Nuclear Factor-KappaB), which suppresses inflammation and the expression of pro-survival genes.

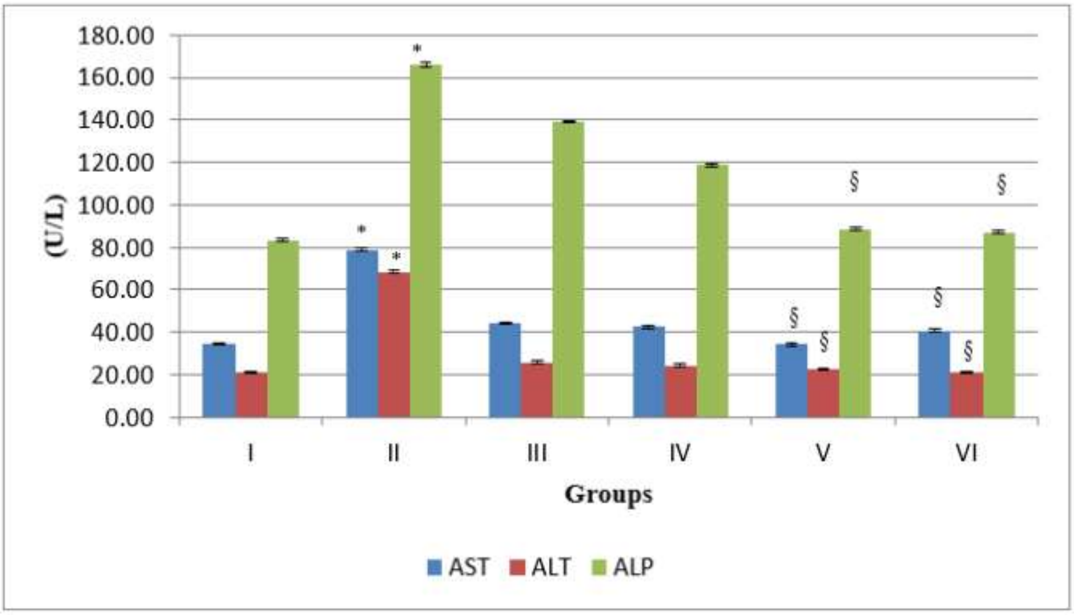

Figure 4:measurement of ALP, ALT, and AST

Red algae generate brominated metabolites, such as terpenoids and phenols, that have anticancer properties via inducing cell toxicity. Furthermore, rather than existing as established treatments, macromolecules like green algal polysaccharides are currently being studied. Although studies have shown that they can suppress angiogenesis, elicit immunological responses, and cause apoptosis, more preclinical and clinical trials are necessary to determine their safety and effectiveness.

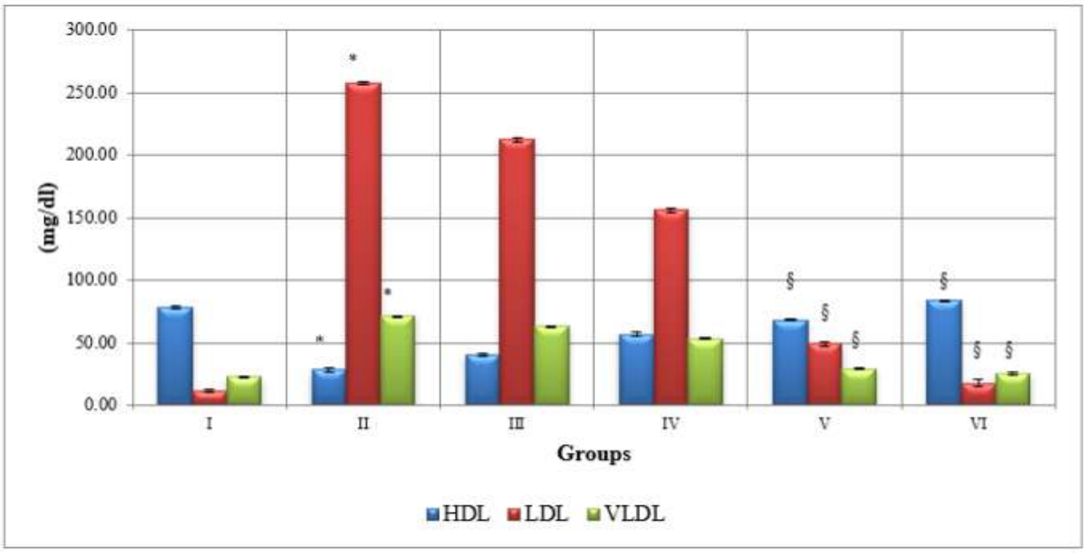

Figure 5: measurement of HDL, LDL and VLDL

Although marine algae are a remarkable source of bioactive metabolites, their potential for use in medicine has only been partially investigated due to issues with scale-up production, extraction efficiency, and associated clinical data. More research is required, as indicated by the requirements for complete molecular characterisation, enhanced purification techniques, and green extraction.

5. CONCLUSION

A viable, sustainable, and attractive substrate for the synthesis of biopolymers with antiviral and anticancer chemicals that could address significant global health concerns is marine algae. Their bioactive substances, which include polysaccharides, polyphenols, alkaloids, and terpenoids, have multiple action pathways that include immunomodulation, induction of cancer cell death, and antiviral activity. However, the ecological advantages of growing algae, such as the ability to use seawater and area that has never been farmed before, make them a sustainable resource. Despite this, a number of challenges remain, including the difficulty of isolating single bioactive compounds, scalability of production, and toxicity and bioavailability issues. Utilizing the full medicinal potential of marine algae will require new biotechnology developments, such as genetic engineering and bioreactor technologies, together with a better understanding of the unique marine ecosystem. By integrating multidisciplinary strategies, marine algae are well-positioned to become the basis of novel, efficient, and natural treatments for viral diseases and neoplastic disorders. However, large-scale anti-fouling compound metabolic engineering and industrial scale production remain understudied. Climate change presents a great menace to seaweeds, benthic seaweed communities, and ecosystem benefits; thus, studies on resistant strains and environment-friendly culture techniques must be established.

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