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Review

A Comprehensive Review on *Sargassum plagiophyllum*: A Versatile Marine Resource

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	Abstract
Published on: 30 Dec 2024	<p>Sargassum plagiophyllum, a brown alga belonging to the Sargassaceae family, has emerged as a promising marine resource with diverse applications. This review delves into the multifaceted aspects of this alga, including its taxonomy, ecology, biochemical composition, and pharmacological properties. The alga thrives in intertidal and subtidal zones, exhibiting a unique morphology characterized by its holdfast, stem, branches, and leaves. <i>S. plagiophyllum</i> is a rich source of bioactive compounds, particularly polysaccharides like fucoidan and laminarin, and polyphenols such as phlorotannins. These compounds possess a wide range of pharmacological activities, including antioxidant, anti-inflammatory, anticancer, antimicrobial, anticoagulant, antiviral, antidiabetic, neuroprotective, hepatoprotective, and immunomodulatory effects. Recent studies have highlighted the anticancer potential of fucoidan extracted from <i>S. plagiophyllum</i>, which has been shown to inhibit tumor growth and metastasis. Additionally, the alga's extracts have demonstrated significant antimicrobial activity against various pathogens, including bacteria and fungi. Moreover, <i>S. plagiophyllum</i>-derived compounds have exhibited promising anti-dengue activity, suggesting their potential as therapeutic agents. In conclusion, <i>S. plagiophyllum</i> offers a wealth of opportunities for the development of novel drugs and functional foods. Further research is needed to fully explore its potential and to optimize its sustainable harvesting and utilization.</p>
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INTRODUCTION

The genus *Sargassum*, a diverse group of brown algae within the family Sargassaceae, has captivated the attention of researchers and industries alike. These marine macroalgae, distributed across temperate and tropical oceans worldwide, are renowned for their ecological significance, nutritional value, and potential applications in

various fields. This review delves into the multifaceted aspects of Sargassum, exploring its taxonomy, ecology, biochemistry, and potential applications.

Taxonomy and Classification

The genus Sargassum was first described by C. Agardh in 1820. It is a complex and diverse group, with numerous species exhibiting a wide range of morphological variations. Traditional taxonomic classification relied heavily on morphological characteristics, such as the presence and arrangement of vesicles, leaf-like structures, and reproductive organs. However, recent advances in molecular biology have led to a more refined understanding of Sargassum phylogeny.

Molecular studies have revealed that the genus Sargassum is not monophyletic, suggesting that it may be divided into multiple genera. Nonetheless, the genus remains a taxonomically challenging group, and further research is needed to clarify its phylogenetic relationships.

Ecology and Distribution

Sargassum species exhibit a wide range of ecological strategies, from benthic to pelagic. Many species are benthic, attaching to rocks, corals, or other substrates in shallow coastal waters. Others, such as *S. natans* and *S. fluitans*, are pelagic, forming extensive floating mats in the open ocean.

The distribution of Sargassum is influenced by various factors, including water temperature, salinity, nutrient availability, and ocean currents. These algae are particularly abundant in tropical and subtropical waters, where they form dense beds and contribute significantly to marine ecosystems.

Ecological Significance

Sargassum plays a crucial role in marine ecosystems. Its dense mats provide habitat and shelter for a diverse range of marine organisms, including fish, invertebrates, and microorganisms. These algae also contribute to primary productivity, providing energy and nutrients to the food web. Furthermore, Sargassum can help stabilize sediments, reduce erosion, and improve water quality by absorbing excess nutrients.

However, excessive growth of Sargassum can lead to negative ecological impacts. Large-scale blooms, often referred to as "golden tides," can smother coral reefs, deplete oxygen levels in the water, and harm marine life. These blooms can also have significant economic and social consequences, affecting tourism, fisheries, and coastal communities.

Habitat and Growth

This species thrives in the challenging environment of rock pools within the lower intertidal zone and extends into the subtidal zone. The optimal growth period for this species is from October to March.

Vegetative Features

- **Holdfast:** The plant anchors itself to the substrate using a discoidal holdfast, typically 2-5 mm thick and 5-10 mm in diameter.
- **Primary Stem:** The primary stem is cylindrical, reaching up to 10-13 mm in length and 2-3 mm in diameter. It often exhibits scars from fallen main branches in its lower section.
- **Branches:**
 - **Main Branches:** Two to four main branches emerge from the middle part of the primary stem. These branches are compressed at the base and cylindrical towards the tip, measuring 18-90 cm in length and 1-3 mm in width. They lack ridges and spinous processes.
 - **Secondary and Tertiary Branches:** These branches are cylindrical, ranging from 1.5-15.0 cm and 0.5-2.0 cm in length, respectively. They are 0.5-1.0 mm and 0.3-0.5 mm in width, respectively, and devoid of ridges and spinous processes.
- **Leaves**
 - **Primary Stem Leaves:** Simple, lanceolate to linear, with serrate margins, 3-5 cm in length.
 - **Main Branch Leaves:** Simple, oblong, lanceolate to linear, 0.5-1.5 cm apart, arranged in an alternate to spiral pattern. Leaf blades are thin, shortly stalked, with asymmetrical bases, evanescent midribs, and obtuse to acute tips. Margins are entire or irregularly and shallowly serrate.
 - **Secondary and Tertiary Branch Leaves:** Simple, oblong to linear, 2-3 mm and 0.5-1.0 mm apart, respectively, arranged in a spiral pattern. Leaf blades are thin, shortly stalked, with asymmetrical bases, indistinct or absent midribs, and obtuse or acute tips. Margins are entire to irregularly serrate.

Reproductive Features

- **Dioecious:** Male and female reproductive structures are borne on separate plants.

- **Male Receptacle Branches:** Racemously arranged, not carpophyllaceous, cylindrical, smooth or warty, irregularly forked, 5-10 mm long, 0.5-1.0 mm in diameter, with a tapering tip. They are typically found in the axils of leaves and vesicles of tertiary branches.
- **Female Receptacle Branches:** Cymosely arranged, sometimes carpophyllaceous, compressed or triangular, smooth at the base and middle but slightly spiny at the tip, irregularly forked, 1-2 mm long, 0.5-1.0 mm wide. They are mostly found in the axils of leaves and vesicles of tertiary branches.
- **Antheridia:** 16-30 μm long, 12-20 μm in diameter.
- **Oogonia:** 90-140 μm long, 70-85 μm in diameter.

Biochemical Composition and Bioactive Compounds

Sargassum species are rich in various bioactive compounds, including polysaccharides, polyphenols, pigments, and minerals. These compounds have been linked to numerous health benefits and potential applications in various industries.

Polysaccharides: Sargassum polysaccharides, such as fucoidan, laminarin, and alginate, have attracted considerable attention due to their diverse biological activities, including antioxidant, anti-inflammatory, anticoagulant, and antitumor properties.

Polyphenols: Phlorotannins, a type of polyphenol found in Sargassum, possess potent antioxidant and antimicrobial properties. They can help protect cells from oxidative damage and inhibit the growth of harmful bacteria.

Pigments: Sargassum contains pigments like fucoxanthin, which has been shown to have antioxidant, anti-inflammatory, and anti-obesity effects.

Minerals: Sargassum is a good source of essential minerals, including iodine, calcium, magnesium, and potassium, which are important for human health.

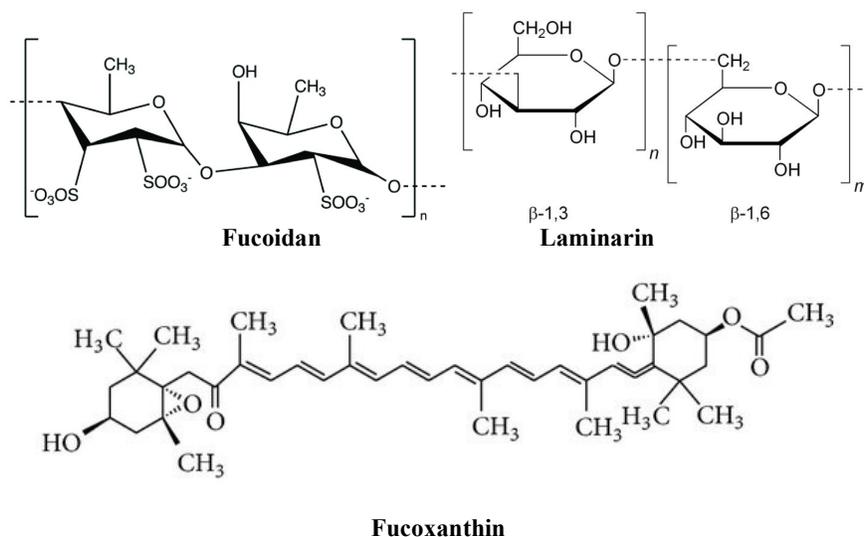


Table 1: Biological activities reported

Biological Activity	Compounds Involved
Antioxidant	Polysaccharides (fucoidan, laminarin), polyphenols (phlorotannins)
Anti-inflammatory	Polysaccharides (fucoidan), polyphenols
Anticancer	Fucooidan, other polysaccharides
Antimicrobial	Polyphenols, terpenoids
Anticoagulant	Fucooidan
Antiviral	Fucooidan, other polysaccharides
Antidiabetic	Polysaccharides
Neuroprotective	Polysaccharides, polyphenols
Hepatoprotective	Polysaccharides, polyphenols
Immunomodulatory	Polysaccharides

Pharmacological activity**Anti-cancer activity**

Fucoidan, a complex polysaccharide isolated from *Sargassum plagiophyllum*, demonstrated significant anticancer properties against diethylnitrosamine (DEN)-induced hepatocarcinogenesis in rats. The purified fucoidan, rich in sulfate groups and primarily composed of fucose, was found to restore the activity of key mitochondrial enzymes (ICDH, SDH, MDH, α -KGDH) and phase I and II biotransformation enzymes that were compromised in cancer-bearing rats.

The phenolic compounds extracted from *Sargassum plagiophyllum* demonstrated significant cytotoxicity against human cervical (HeLa and SiHa) and colon cancer cell lines (HCT116 and PMF-k014). The concentrations varied significantly between life phases, with young plants having the lowest concentration. Total phenolic compounds shown antitumor efficacy against cervical cancer cells (HeLa and SiHa) and colon cancer cells (HCT116 and PMF-k014). substances shown antitumor efficacy against cervical cancer cells (HeLa and SiHa) and colon cancer cells (HCT116 and PMF-k014). Half-maximal inhibitory doses (IC50 values) of $>80 \mu\text{g/ml}$ were obtained by the extracted phenolics' cytotoxic activity against the cell lines HCT116 and PMF-k014, and 44 ± 11.4 and $41.9 \pm 6.1 \mu\text{g/ml}$ against HeLa and SiHa.

Antimicrobial effect

Gold nanoparticles (GNPs) synthesized using extracts from the seaweed *Sargassum plagiophyllum*. Characterization studies revealed a mean particle size of 65.87 nm. The antimicrobial activity of these GNPs was evaluated against *Salmonella typhi* and *Escherichia coli*. Microscopic analysis, including atomic force microscopy (AFM) and field emission scanning electron microscopy (FE-SEM), revealed significant morphological changes in bacterial cells treated with GNPs. These changes included membrane damage, cell lysis, and alterations in cell shape. To further visualize the antibacterial effect, fluorescence microscopy was employed. Dead cells were stained orange, while live cells were stained green.

Antidengue Activity

According to the findings, fucoidan exhibited anti-dengue activities with an effective concentration (EC50) of 76.49 $\mu\text{g/ml}$ and a selectivity index (SI) of 3.02. Fucoidan from *S. plagiophyllum* was shown to have the most anti-dengue effect in *Aedes aegypti* (EC50 = 76.49 $\mu\text{g/ml}$). Furthermore, a CC50 value of higher than 50 $\mu\text{g/ml}$ was considered to indicate harmless effects. The Vero cells did not exhibit any harmful effects, as evidenced by the cytotoxicity of fucoidan, which was 219.56 $\mu\text{g/ml}$. When compared to Vero cells, the compound's selectivity index (SI) value of 2.87 demonstrated its capacity to kill plasmodium specifically. When an extract's SI value was less than 5 and over 2.0, it was categorized as having low selectivity. Despite being categorized as weak, fucoidan's SI was not hazardous since it only killed the dengue virus and had no effect on the host. *S. plagiophyllum*'s anti-dengue fucoidan action was less potent than that of polysaccharide sulfate.

CONCLUSION

Sargassum, a diverse genus of brown algae, holds significant ecological, nutritional, and industrial potential. Its complex taxonomy and wide distribution across various marine environments highlight its adaptability and resilience. The genus plays a crucial role in marine ecosystems, providing habitat, food, and oxygen, while also contributing to nutrient cycling and sediment stabilization. The biochemical composition of *Sargassum*, rich in polysaccharides, polyphenols, pigments, and minerals, offers a wide range of potential applications. These bioactive compounds have demonstrated various pharmacological activities, including antioxidant, anti-inflammatory, anticancer, antimicrobial, anticoagulant, antiviral, antidiabetic, neuroprotective, hepatoprotective, and immunomodulatory effects. Further research is needed to fully explore the potential of *Sargassum* as a valuable resource for various industries, including pharmaceuticals, food, and cosmetics.

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