

Bioactive Compounds from Seaweed: Unlocking Their Potential

Panneerselvam Dheeran

ICAR- Central Institute of Fisheries Education, Mumbai

SUMMARY

Seaweed is a rich source of diverse bioactive components, contributing to its unique properties. This article focuses on the bioactive compounds present in seaweed and their potential applications in the pharmaceutical industry. Using seaweed as a source of protein, minerals, vitamins, dietary fiber, antioxidants, and essential fatty acids, these compounds are expected to contribute significantly to health and industry domains, establishing them as valuable resources across various sectors. These marine organisms have various biological activities, including anti-inflammatory, antiviral, anticancer, antithrombotic, anticoagulant, and antioxidant properties. In addition, seaweed polysaccharides, extracted from different algae cell walls, exhibit a diverse range of bioactivities, including immunomodulation, anti-inflammation, and anti-HIV activities. These compounds show promise as valuable additions to functional foods and nutraceuticals, serving not only as health supplements but also potentially as practical components in the development of marine drugs for cancer treatment.

INTRODUCTION

Seaweed is a collective term for numerous species of marine plants and algae that flourish in oceans, rivers, lakes, and other water bodies, including various types of Rhodophyta (red), Phaeophyta (brown), and Chlorophyta (green) macroalgae. Seaweed contains diverse bioactive components, contributing to its unique properties. In various industries, particularly the food sector, seaweed plays a multifaceted role, serving as an excellent source of protein, minerals, vitamins, dietary fiber, antioxidants, and essential fatty acids, all with a low caloric value. It's crucial to acknowledge that different types of seaweed offer distinct nutritional profiles. For example, red seaweeds like Nori are abundant in protein, vitamins, and minerals, while brown seaweeds like Kelp may supply iodine and other nutrients. Furthermore, certain types of seaweed find applications in the pharmaceutical industry due to their antibacterial, antiviral, and antifungal properties (Brown *et al.*, 2014). These adaptable marine organisms significantly contribute to nutritional and medicinal domains, establishing them as valuable resources across various sectors. Bioactive compounds are essential for preventing illness and preserving physiological function. This article will discuss the present seaweed bioactive components and its effective utilization.

Polysaccharides

Polysaccharides found in seaweed, extracted from the cell walls of different algae, exhibit a diverse range of bioactivities, including immunomodulation, anti-inflammatory, antiviral, anticancer, antithrombotic, anticoagulant, and antioxidant properties (Hentati *et al.*, 2020). These complex carbohydrates, formed by joining smaller monosaccharides with the help of specific enzymes, are commonly referred to as glycans or polysaccharides. The concentrations of these polysaccharides in seaweed species vary, ranging from 4% to 76% of dry weight. Species like *Ascophyllum*, *Porphyra*, and *Palmaria* have exceptionally high contents, and even green seaweed species like *Ulva* boast concentrations of up to 65% polysaccharides of dry weight. Beyond their natural habitat, seaweed polysaccharides, including notable types like fucoidans, laminarans, and alginates, are extracted for their health benefits. Fucoidans are recognized for their anti-inflammatory, antioxidant, antiviral, and anticancer properties, while laminarans exhibit immunomodulatory and antioxidant effects. Additionally, alginate, a significant component in seaweed cell walls, is being explored for pharmaceuticals and dietary fiber applications. This versatility makes seaweed polysaccharides valuable in various industries, including food, pharmaceuticals, and cosmetics, with ongoing research aiming to unveil their complete range of health-promoting attributes.

Vitamins

Using vitamins from natural sources like seaweed has significant potential in nutraceuticals or functional foods (Škrovánková, 2011). Vitamins provide essential functions for the body and offer antioxidant benefits and other health advantages. Certain people, such as those on special diets or smokers, are prone to vitamin deficiency.

Vitamin deficiency can result from insufficient intake, increased requirements, poor absorption, or inadequate utilization. Nutraceuticals or functional foods could be beneficial for them in restoring good health. Seaweeds, mainly red algae like Nori, are:

- Rich sources of B group vitamins (B1, B2, B12).
- Antioxidants like vitamins C and E.
- Provitamins A (Carotenoids like beta-carotene).

Notably, seaweed contains high levels of vitamin B12, which is crucial for those on a vegan diet. Vitamin C, known for its antioxidant properties, has been linked to a reduced risk of stomach cancer. Despite seaweeds having low lipid content, their fat contains abundant vitamin E, positively influencing mortality from cerebrovascular diseases and reducing the risk of lung and cervical cancers. Research suggests a connection between a diet rich in beta-carotene and a lower risk of cardiovascular diseases and decreased lung cancer risk. Exploring seaweed vitamins for nutraceuticals or functional foods presents promising possibilities in the food industry. Consumers, especially those with specific health needs, can benefit from the added health properties of such foods.

Proteins

Seaweeds have protein content ranging from 10% to 40% per dry weight, varying with the seasons and species (Pangestuti and Kim, 2015). Red seaweeds generally have higher protein levels, reaching almost 50% of dry weight, compared to green and brown seaweeds. These protein levels in red seaweed are similar to those found in high-protein vegetables like soybeans, where proteins make up around 35% of the dry mass. This variation in protein content can be influenced by factors such as the type of seaweed, the time of year, and environmental conditions. With their comparatively higher protein content, red seaweeds present a valuable source of plant-based protein, similar to other protein-rich foods like soybeans. Incorporating seaweeds into diets can contribute not only to protein intake but also to the overall nutritional diversity.

Protein Profile Reported of Individual Seaweed Species Per Dry Weight

Seaweed Species	Protein (%)
<i>Enantiocladia duperreyi</i>	19.50 ± 1.50
<i>Porphyra yezoensis</i>	31.00–44.00
<i>Ulva compressa</i>	21.00–32.00
<i>Sargassum vulgare</i>	16.30 ± 1.30

Source: (Pangestuti and Kim, 2015)

Seaweed proteins include two critical groups: **Lectins** and **Phycobiliproteins**. Lectins and glycoproteins bind with carbohydrates and play roles in biological processes like intercellular communication. They can agglutinate red blood cells in seaweeds such as *Eucheuma sp.*, *Solieria filiformis*, and *Gracilaria cornea*. Lectins from seaweeds have demonstrated antibacterial, antiviral, anti-inflammatory, anticancer, and anti-HIV activities.

Phycobiliproteins, on the other hand, are stable and soluble fluorescent proteins in red seaweeds. They contain tetrapyrrole groups linked to their structure, aiding in light collection for photosynthesis. There are three main types: phycocyanin, allophycocyanin, and phycoerythrin. Phycoerythrin, a primary light-harvesting pigment in red seaweeds, is often used as a fluorescent probe in scientific experiments. The unique structure of allophycocyanin and phycoerythrin allows some red seaweeds to survive in relatively deep water where chlorophyll absorbs poorly (450–650 nm).

Carotenoids

The content of carotenoids in seaweed is driving a rapid increase in their commercial value, with applications extending widely into various industries, including functional foods and nutraceuticals. Seaweed carotenoids, such as β -carotene, astaxanthin, and fucoxanthin, offer significant health benefits and are becoming increasingly popular (Abu-Ghannam and Shannon, 2017). In the context of cancer prevention, these carotenoids play a crucial role, contributing to strategies for controlling cancer. Studies have shown that including carotenoids in the diet can lower the risk of various types of cancers. β -carotene, a significant source of vitamin A, not only acts as a potent antioxidant but also has demonstrated the ability to suppress cancer development when supplemented.

Carotenoid	Source	Health Properties
Fucoxanthin	Edible marine sources, nutraceutical supplements	Antioxidant, anti-obese, antidiabetic, cancer prevention
Astaxanthin	Seafood (e.g., salmon, shrimp)	Potent antioxidant, general health benefits
Lutein & Zeaxanthin	Seaweeds	Maintains eye health and reduces the risk of age-related macular degeneration (AMD)
β -Carotene	Various fruits and vegetables	Supports immune function, overall health

Different marine carotenoids

Astaxanthin is known for its powerful antioxidant properties, as well as its anti-inflammatory and anticancer properties. Fucoxanthin, primarily found in brown algae, is recognized for its multifaceted activities, including antioxidant, anti-inflammatory, anticancer, antidiabetic, and antiangiogenic properties.

Seaweed carotenoids are gaining attention in the pharmaceutical industry with their diverse health benefits. These compounds show promise as valuable additions to functional foods and nutraceuticals, serving not only as health supplements but also potentially as practical components in the development of marine drugs for cancer treatment. The growing interest in these seaweed carotenoids reflects their potential to contribute significantly to health and industry.

CONCLUSION

In conclusion, seaweed is a valuable marine resource rich in bioactive components like polysaccharides, vitamins, proteins, lectins, phycobiliproteins, and carotenoids, offering diverse health benefits. These components have applications in various industries, including food, pharmaceuticals, and cosmetics, showcasing the potential of seaweed as a versatile and beneficial resource for human health and well-being.

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