

Seaweeds are traditional chinese medicines with abundant medicinal and pharmacological properties

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Abstract

From past 3 epochs, seaweeds are having utmost recognition because of the properties they provide us for healthy leading lifestyle. Sea is abode for vast variety of marine species and represented as a huge storage of pharmacologically important algae. The marine species are chief organisms embedded with novel bioactive compounds from which natural molecules can be extracted and tested for its toxicity before being used as therapeutic substance. Amongst various marine species, seaweeds have attained much importance for their medicinal properties and revealed to have their antioxidative, antimicrobial, antifungal, anti-inflammatory, antidiabetic and anti-tumor actions. Investigations have been done individually in various cases in respect to their necessity. Several resource databases, literature data also revealed that seaweeds obtained from marine algae such as Chlorophyta, Phaeophyta and Rhodophyta are abundant with medicinal properties and currently several pharmaceutical companies started using this resource for development of drugs against tumors, cancers, AIDS, and Corona virus. Currently, our article will provide broad insights on remedial along with pharmacological actions and specific emphasis on the current pandemic disease with respect to the mechanism of action and future directions for researchers.

Key words : Seaweeds, Medicinal Properties, Anti-fungal, Anti-viral, Anti-tumor, Corona virus.

Our Earth is flooded with 70% of many acts as a resource for providing raw aquatic species. Amongst abundant species materials, tourism & cultural heritage.

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Seaweeds or macroalgae are ample in every marine ocean which photosynthetic algae rich in nutrition and used as Chinese traditional medicine from long ago. These seaweeds can be grouped into three main classes: Chlorophyta (green algae), Phaeophyceae (brown algae) and Rhodophyta (red algae)^{19,40,57}. With recent advancements in biotechnology, utilization of seaweeds for their interesting bioactive compounds attracted pharmaceutical companies to grow these edible seaweeds which are cheap, non-toxic, and can act as better candidates in replacing synthetic drugs.

Moreover, they are utilized conventionally as nutrition, fertilizers, dyes. Agar, Carrageenan, and Alginate which are hydrocolloids are commonly used components due to their biotechnological and pharmaceutical applications^{56,72}. From the last three decades acknowledging the significance of seaweeds as functional foods resulted in recommendations for dietary in addition to their macronutrient content. For therapeutic products, seaweeds are extracted for metabolites that contain biological activity^{12,70}.

Global dietary studies have revealed that countries where seaweed is taken consistently resulted in decreased diet-related diseases and obesity^{24,45}.

Seaweeds are rich source of bioactive compounds like phlorotannins and certain polysaccharides that has health improving benefits. The intake of seaweeds in our diet helps to diminish the prevalence of chronic ailments such as coronary heart disease, cancer and Hyperlipidemia³⁰. From decades edible seaweeds are recommended as dietary food for humans due to their rich source of

natural antioxidants, anti-inflammatory and anti-microbial actions²¹. Seaweed polysaccharides are rich source of soluble and insoluble dietary fibres and they show more water holding capacity compared to cellulosic fibers. In addition to soluble dietary fibers seaweeds display property of viscosity, gel formation and function as emulsifiers¹⁷.

Seaweeds are having a significant abundance of vitamins *i.e* A, B1, B2, B9, B12, C, D, E, and K along with indispensable minerals such as phosphorus, zinc, selenium, calcium, magnesium, iodine, iron, copper, manganese, fluoride, potassium^{15,51}. The macroalgae are also rich in dietary fibers, proteins, polyphenols, essential amino acids which have the potential to reduce reactive oxygen species formation, and further display anti-inflammatory, anti-viral, anti-tumor activity^{32,47,50,55,60}.

Since seaweeds have been consumed traditionally by Japanese in their diet. However, seaweed consumption was highest among Japan in comparison to other countries⁶. Nonetheless, due to incredible health benefits^{10,41,52} lays for basis of hypothesis that use of these dietary rich seaweeds could to limit severity of the COVID19 pandemic. Therefore, our review provides insights on medicinal properties and pharmacological effects of the seaweeds on various ailments and could possibly be solution against COVID-19.

Literature reports of seaweeds antiviral activity :

In contemporary years, the constant outbreak of new emerging as well as re-emerging

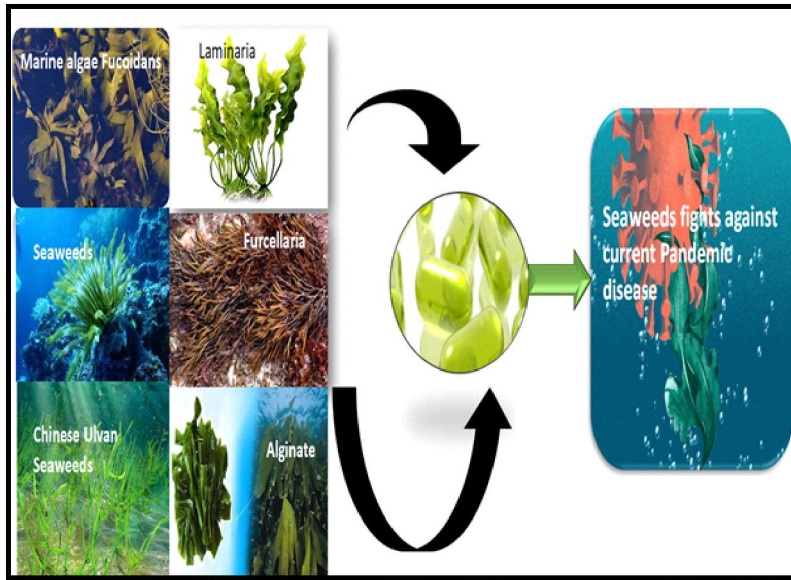


Fig. 1. Seaweeds have the potential to fight against the current pandemic COVID-19 and have revealed their anti-viral activity.

of viral infections has posed serious threat to human health. The antiviral activity of marine algal polysaccharides was first revealed by¹⁸, on polysaccharides especially extracted from the *Gelidium robustum* previously named as *Gelidium cartilagineum* belonging to red alga (Rhodophyta) observed to protect embryonic eggs against mumps virus/ influenza B virus. Several marine algae species and members of Nidovirales possess considerable quantities of complex structural sulphated polysaccharides which been displayed its potentiality in refraining the enveloped viruses replication. However, certain other compounds, such as lectin (griffithsin) and other sulphated polysaccharides extracted from green algae (*i.e.* ulvans) along with brown algae (*i.e.* fucoidans) revealed to have potential antiviral therapeutic compounds against SARS-CoV-2^{4,5,9,48,53,59,62}.

Importance of seaweeds pharmacological studies and its application :

The extensive use of terrestrial plant-based resources resulted in finding for new resource in order to improve human health. However, researchers shifted their attention on marine drugs to obtain better feats. Nonetheless, several in vitro and in vivo tests were conducted to assess biological compounds present in marine organisms. Amongst marine organisms, seaweed was exploited for their pharmacological activity⁴⁴. Few species of seaweeds were analysed and reported such as *Chaetomorpha antennina*, *Ulva lactuca*¹, *Sargassum wightii*¹³ and *Sargassum cinereum*¹⁴. Later, pharmacokinetic studies on active molecules laid for the next step in drug development which shows how a drug reveals its response after administration inside the body

Table-1. Principal sources of Seaweeds and their Importance and its Application Properties

Principal Sources	Class of Seaweeds rich in bioactive compounds	Application and Properties	References
Brown seaweed (Undaria pinnatifida, Fucus sp.)	Polysaccharides -Fucoidan	Antimicrobial Antiproliferative, Anticoagulant activity Antidiabetic activity and Antiviral activity	3,26,33,37, 49,54,61,
Brown seaweed (Laminaria sp.)	Polysaccharides -Laminarin	Produced by food industry & biomedicine for its nutraceutical properties; antitumour antioxidant activity and immunostimulatory	11,36,64
Brown seaweed (Laminaria sp., Ascophyllum nodosum)	Polysaccharides -Alginate	In food products and medicine used as stabilizer and thickening agent	58, 65
Red Seaweed (Gracilaria sp.) Red seaweed (Gigartina sp., Chondrus sp.)	Polysaccharides -Agar Polysaccharides-Carrageenan	Used in food products and pharmaceutical field as jellifiers, stabilisers, thickeners and emulsifiers	7,71.23
Red seaweed (Porphyra sp.)	Polysaccharides - Porphyran	Anti-oxidant, Anti-inflammatory Anti-hyperlipidemic and Anti-cancer activities	35, 38, 66,
Green seaweed (Ulva sp.)	Polysaccharides -Ulvan	Anti-tumoral, Immunostimulatory Antiviral activities	2, 42, 46
Brown seaweed (Ecklonia sp., Eisenia sp., Laminaria sp., Undaria pinnatifida)	Polyphenols - Phlorotannin	Anti-oxidant, Antimicrobial, Antiviral, Anticancer, anti-inflammatory, Antidiabetic properties	25, 30

of an organism. The distinct understanding of pharmacokinetics studies how a drug acts after administration via the processes of absorption, distribution, metabolism and excretion (ADME). The understanding of the pharmacokinetics of

marine-derived polysaccharides has led to their potential use in pharmaceutical formulations^{27,63}. In Table-1 have listed different classes of seaweeds and its application properties.

Table-2. List of compounds extracted from seaweeds and their pharmacological activity

Seaweed	Pharmacological Actions	Compound extracted	Cell lines/ Animal Models	Administration route	References
Fucus evanescens (Phaeophyceae)	Anti-coagulant actions both <i>in-vitro</i> and <i>in-vivo</i> conditions	Fucoidans	Human plasma Rat plasma	Intravenous Injection	⁶⁹
Laminaria cichorioides (Phaeophyceae)	Anti-coagulant activity <i>in-vitro</i>	Sulphated fucan	Human Plasma	The crude extract was lyophilized polysaccharide was suspended in human plasma	²⁰
Gracilaria edulis (Rhodophyceae)	Hypoglycaemic Actions	Flavonoid, Phenolic, and Alkaloid compounds	Bovine serum albumin (protein)	The extracts tested on protein	²⁸
Sargassum-fulvellum (Phaeophyceae)	Anticoagulant, Antioxidant, anticancer, anti-inflammatory, antibacterial activities	fucoidan Phlorotannins, ketone, polysaccharides grasshopper	Mice	Oral Administration	⁴³
Griffithsia sp. (Rhodophyceae)	Antiviral actions against MERS-CoV virus as well as SARS-CoV glycoprotein	Griffithsin (protein)	In vitro cell lines SARS-CoV and MERS-CoV glycoproteins	The extracts were tested on the proteins	³⁴
Saccharina japonica (Phaeophyceae)	Inhibition of SARS-CoV-2 In-Vitro	Polysaccharides	SARS-CoV-2 S-protein	The extracts were tested on the protein	³⁴

Traditional Seaweeds and their application in modern pharmacology :

The seaweeds are used from ancient

times to treat infections related to alimentary canal and have abundance medicinal properties from ancient times, specifically in Asian countries^{67,68} even earlier researchers have

acknowledged its pharmacological actions. For instance Chinese have demonstrated on the crude extract of brown seaweed *Sargassum naozhouense* which has been utilized for treating infections such as laryngitis, fever and other ailments among the local population²². In Vietnam seaweed species of *Kappaphycus* and *Eucheuma* genera are specifically used in the field of medicine to mitigate the formation of tumors, headaches and ulcers. The another species of seaweed termed *Sargassum* is used for treatment of iodine deficiency such as goitre³⁹. From ancient times of around 1061 AD use of *Sargassum* sp. And its medicinal properties have been examined and stored in Chinese medical books called “Compendium of Materia Medica”, written by Shizhen Li in 15th century. The book provides information about the algae *Sargassum* and its potential to treat thyroid related diseases such as goitre, and also highlights about dispel nodes, how to soften hard lumps, dismissal of phlegm and in certain cases instigation of urination in humans¹⁶. In Table-2 have depicted Seaweeds Bioactive agents and their Pharmacological actions.

The seaweeds have been recognized from ancient times and most of Japanese use this seaweeds regularly in their diet which contains abundant bioactive compounds which exert anti-inflammatory, antioxidant, as well as antiviral activity directly or indirectly, by enhancing the gut microbiome. Nonetheless, orally taken seaweeds has revealed to exert candid antiviral activity against SARS-CoV-2 within the intestine through release of fucoidan and other bioactive components. Yet, further research to be carried out before formulation of the marine algae into therapeutic drug. Our article provides future directions to all scientists

and researchers to significantly find a prompt solution to the current pandemic COVID-19 disease.

Author contributions :

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Contributions :

KRP and KRD contributed in writing, drawing figures and tables in this review article. KRP solely drafted this article. All authors approved for submission.

Compliance with ethics Requirements

Nil

Conflict of interest

None

Data availability

The data presented in this study are available from the corresponding author on reasonable request.

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