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A Review on Bioactivities and Biomass Technique from Marine Algae

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ABSTRACT

Numerous bioactive chemicals with economic potential in the pharmaceutical, medical, cosmetic, nutraceutical, food and agricultural industries are found in marine algae. The most important source of structurally distinct natural products, which are mostly found in living things, is the ocean. In instinctive product research, the vital products derived from marine microorganisms and marine algae are closely examined. Marine algae are a novel diet that have the potential to be nutritious and are employed in industry and medicine for a variety of applications. An enormous supply of naturally occurring bioactive chemicals with antidiabetic, anti-inflammatory, antiviral, antifungal, hypolipidemic, antioxidant, anti-hypercholesterolemia, antibacterial and antineoplastic qualities has also been demonstrated to be provided by marine algae. Phlorotannins, fatty acids, polysaccharides, peptides and terpenes are among the pharmacologically active substances found both macroalgae(seaweeds) and microalgae(diatoms) that inhibit bacterial invasion. Natural antioxidants, which are abundant in algae, are significant bioactive substances that shield cells from oxidative damage and ward against a host of illnesses and aging processes.

Three categories can be made out of the identified bioactivities and potentialities of the marine algal protein sources and alkaloids in this review.

1. Phenylethylamine alkaloids

2. Indole and halogenated indole alkaloids

3. Other alkaloids

The creation of inexpensive, energy-efficient and non-toxic silver nanoparticles has been accomplished by the use of biological processes including plants, algae, fungi and bacteria. Using a green synthesis approach, silver nanoparticles were produced from marine algae *Colpomenia sinuosa*. Various techniques, including UV-Nano photometer, XRD, FT-IR and SEM were used to assess the nanoparticles' characterisation.

KEYWORDS: Marine algae, Alkaloids, Pharmacological activity, Cultivation, Micronutrients and Biomass techniques.

INTRODUCTION:

Marine algae are creatures that resemble plants and are commonly found attached on rocks or other hard surfaces in coastal regions. While green algae can also be found in freshwater environments like rivers and lakes, as well as wet areas like rocks, walls and tree bark, red and brown algae are found in the sea [1]. Phycology is the scientific, ordered study of algae. Bioactive substances such dietary fiber, omega-3 fatty acids, carotenoids, vitamins and minerals can be found in abundance in marine algae [2]. Their cells possess special qualities that are absent from both plants and mammals. Plants and photosynthetic pigments differ from one another. Algae offer a wide range of internal and exterior medicinal benefits [3]. The most valuable resources in the water are marine algae. It makes sense to believe that marine algae could be a valuable resource with abundant source of lipids, proteins, peptides, polysaccharides, polyphenols, amino acids and mineral salts, among other useful metabolites [4]. One class of biomacromolecule found in the structural elements of marine algae's cell walls are polysaccharides. Pharmacological properties as anticoagulant, antioxidant, anticancer and immunomodulatory properties are frequently intimately associated with polysaccharides derived from marine algae [5]. It has been

demonstrated that the active ingredients and cell extracts of different algae exhibit antibacterial action against both Gram-positive and Gram-negative bacteria in vitro. A broad spectrum of findings regarding the antifungal properties of green algae, diatom and dinoflagellate extracts in vitro. Likewise, pharmacologically active chemicals are present in and/or excreted by certain micro-algae that were examined. For instance, the central nervous system is affected by an alkylguanidine chemical produced by the dinoflagellates Gymnodinium and Gonyaulax. Brominated bi-indoles are the cause of the pharmacological activity in Rivularia firma [6].

ALGAL CLASSIFICATION

Algae are primarily divided into three categories:

1. Green algae or chlorophyll A and B-containing algae (Chlamydomonas, Spirogyra and Chara) are known as Chlorophyceae.

2. Brown algae or phaeophyceae, are mainly found in marine environments. They are pigmented with carotenoids, xanthophylls and chlorophylls A and C. (for example, Sargassum, Laminaria and Dictyota).

Rhosophyceae or red algae, include Porphyra, Gracilaria and Gelidium. These algae contain the red pigment r-phycoerythrin.

The fourth kind of algae consists of blue-green algae (BGA) or cyanobacteria, which are sometimes mistaken for seaweed. This kind of algae, often known as slime algae or smear algae, is frequently found in home aquariums where it quickly covers all surfaces [7].

PYTOCHEMICALS PRECENT IN MARINE ALGAE

i) Steroids,

ii) Phlorotannins,

iii) Terpenoids,

iv) Alkaoids,

v) Amino acids,

vi) Alkanes,

vii) Cyclic polysulphides,

viii) Phenolic compounds,

ix) Halogenated ketones,

x) Fatty acids,

xi) Proteins,

xii) Polysaccharides,

xiii) Fibers,

xiv) Minerals,

xv) Vitamins,

xvi) Acrylic acid.

MARINE ALGAE'S ALKALOIDS

The marine algae that are green, brown and red contain alkaloids. Many researchers are interested in algae's chemistry in an effort to create novel medications since algae include molecules with unique functional groups. Because of their pharmacological properties, alkaloids are particularly interesting among these substances. The chemistry of alkaloids has been extensively researched in terrestrial plants, but there haven't been many investigations done on algae. Alkaloids found in macro algae are described along with their pharmacological properties and structure [8]. Meissner originally used the term "alkaloid" in 1819 to describe these "alkali-like" compounds that are present in plants, although it was not well defined at the time. The definition is now: a compound containing one or more nitrogen atoms in a cyclic ring. The term "alkaloid" refers to a wide range of biological amines and halogenated cyclic nitrogen-containing compounds. The latter is unique to marine algae and organisms.

There were none to be discovered in plants on land. Commonsin, an indole derivative isolated from a Penicillium species found on the green alga Enteromorpha intestinalis and leptosins from Leptosphaeria on Sargassum tortillae are two examples of alkaloids identified from sea algae that correlate to pollutants. Beginning in the 18th century, active chemicals from plants were isolated. According to Kappelmayer, the first alkaloid to be separated from a terrestrial plant was morphine in 1805, and the first alkaloid to be obtained from a marine algae was hordenine in 1969. There are currently about 2,000 recognized alkaloids. They are rare in marine algae but common in terrestrial plants.

Three families of alkaloids found in marine algae were identified.

1. Phenylethylamine alkaloids
2. Indole and halogenated indole alkaloids
3. Other alkaloids [9].

1. PHENYELTHYLAMINE ALKALOIDS

PEA or phenylethylamine PEA, also known as phenethylamine or β/2-phenylethylamine, is an aromatic amine consisting of an ethylamine side chain connected to a benzene ring. Important alkaloids are members of the PEA alkaloid group. Numerous synthetic and natural chemicals have it as a precursor. Both plants and animals contain pharmacologically active substances that are replaced PEAs. Simple phenylamines (tyramine, hordenine) and catecholamines (dopamine) are included in this group. The latter was present in terrestrial plants and animals. PEA's structure permits changes on the aromatic ring, terminal amino group and carbons α and β.

SOURCE:

Desmerestia aculeata and *Desmerestia viridis* are two examples of brown maritime algae that contain PEA; *Ceramium rubrum*, *Cystoclonium purpureum*, *Delesseria sanguine*, *Dumontia incrassata*, *Polysiphonia urceolata* and *Polyides rotundus* are examples of red marine algae. Only six red algae *Gelidium crinale*, *Gracilaria bursa-pastoris*, *Halymenia floresii*, *Phyllophora crispa*, *Polysiphonia morrowii* and *Polysiphonia tripinnata* were found to have PEA when the presence of the compound was recently investigated in 17 different maritime algae. *Scenedesmus acutus*, a microalgae, was also shown to contain PEA.

PHARMACOLOGICAL ACTIVITY:

PEA functions as a neurotransmitter and a neuromodulator in the human brain. It has been demonstrated that PEA helps 60% of sad people feel better. It has been suggested that a prevalent type of depression could be brought on by a PEA deficit. Pharmacologically active substances known as substituted PEAs include hormones, stimulants, entactogenes, hallucinogens, anorexics, bronchodilators and antidepressants.

DERIVATIVES OF PHENYLETHYLAMINE [10]:

a) Phenyletheylamine
b) N-acetylphenylethylamine
c) Tyramine
d) N-acetyltyramine

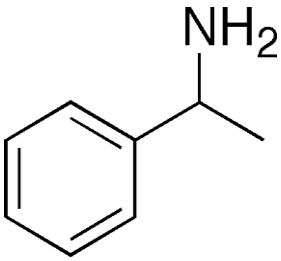
e) Hordenine

f) Dopamine

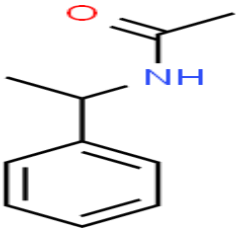
STUCTURE OF PHENYLETHYLAMINE:

PEA; (b) N-ACPEA; (c) TYR; (d) N-ACTYR; (e) HORD; (f) DOP

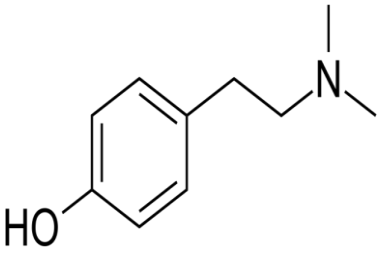
a)Phenyletheylamine



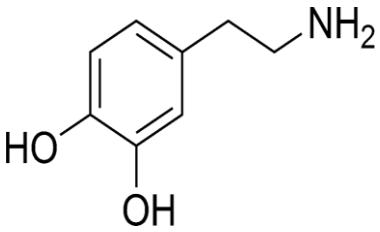
b) N-Acetylphenylethylamine



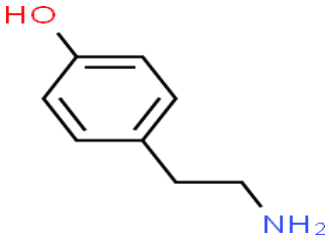
c) Tyramine



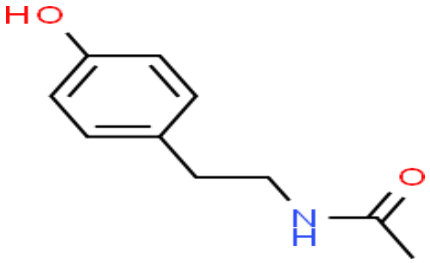
d) N-acetyltyramine



e) Hordenine



f) Dopamine



2. INDOLE GROUP

This class of alkaloids, which includes caulerpin, caulersin, fragilamide, martensine, martefragine, denticine and almazolone is generated from tryptophan and contains a benzylpyrrole.

SOURCE:

Green algae and some red algae were the primary sources of *caulerpin (I)*. Additionally, CLP (I) was separated from the following algae: red; *Laurencia majuscula* (CLP I, II), *Hypnea concornis*, *Caloglossa leprieurii* and *Chondria armata*; green; *Codium decorticatum*, *Halimeda incrassate*. *Caulerpa serrulata* was used to isolate caulersin (CLS). A red alga called *Martensia fragilis* was used to extract *fragilamide* (FRG). *Martensines* (MRT) A and B were isolated from *Martensia fragilis*, a red algae. Three-substituted indoles are MRTs. The red alga *Haraldiophyllum* species yielded almzolone (ALM). One disubstituted derivative of oxazolindole is ALM. Its two stereoisomers, the Z and E isomers that are produced, martch.

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PHARMACOLOGICAL ACTIVITY:

CLP (I) shown no peroxidase activity, antibacterial activity against eight types of bacteria isolated from the algal surface, antifungal activity and modest in vitro anticancer action against crown gall tumor. Strong antioxidant activity was shown by FRG. MRT A demonstrates antimicrobial action against *Mycobacterium smegmatis*, *Staphylococcus aureus* and *Bacillus subtilis*. Denticiens exhibit photooxidative-reduction properties.

DERIVATIVE OF INDOLE GROUP [11-14]:

a) Caulerpin

b) Caulersin

c) Fragilamide

d) Martensine

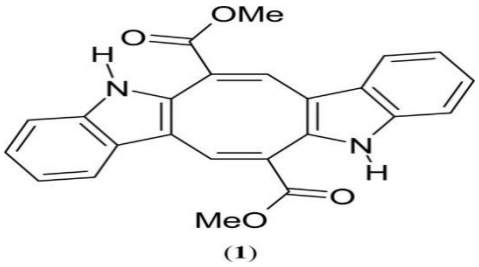
e) Martefragin

f) Denticine

g) Almazolone

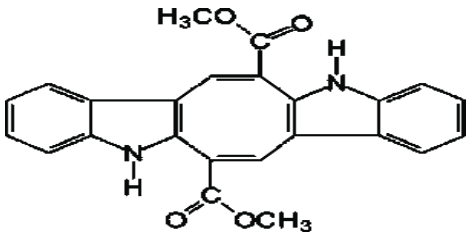
STRUCTURE OF INDOLE GROUP:

a) Caulerpin

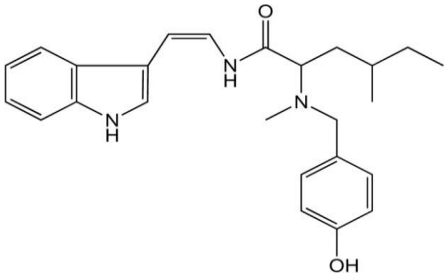


(1)

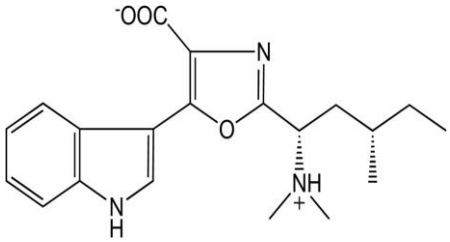
b) Caulersin



c) Fragilamide



e) Martefragine



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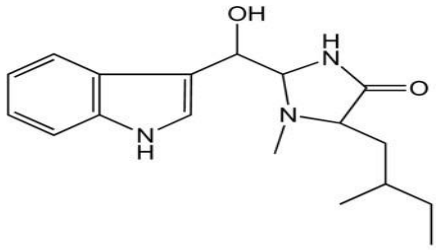
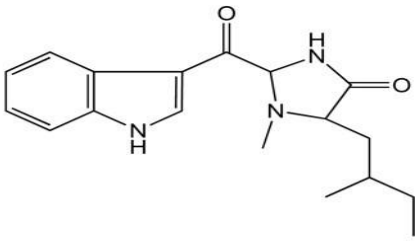
d) Martensine

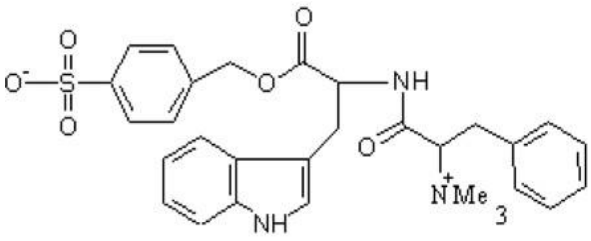


MRT A



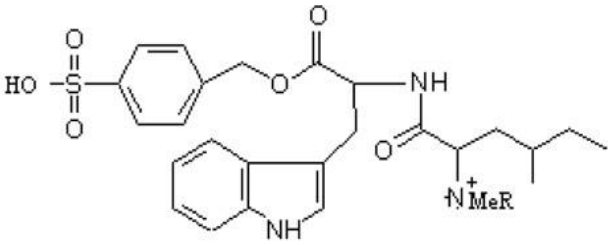
MRT B

f) Denticins



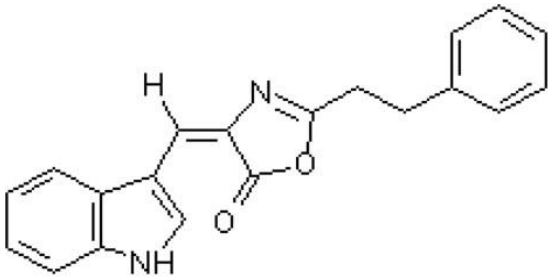
DTC A

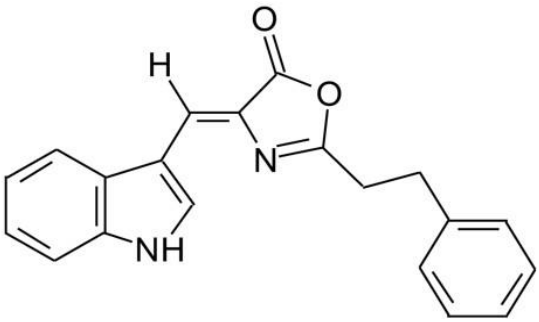
g) Almazolone



DTC B R = H
DTC C R = Me

3. HALOGENATED INDOLE ALKALOIDS [14-16]





Only marine animals and algae were found to contain HLI alkaloids; terrestrial plants did not. Only one HLI alkaloids was isolated from a green alga, but many were from red algae. These alkaloids have atoms of chlorine and bromine in place of an indole group. Additionally, bromoalkaloids containing sulfur were isolated from red algae.

SOURCE:

Laurencia brongniartii, Laurencia similis, Laurencia decumbens.

DERIVATIVES OF HALOGENATED INDOLE ALKALOIDS:

a) Bromoindoles and N-methylbromoindoles

b) Sulfur-containing bromoalkaloids

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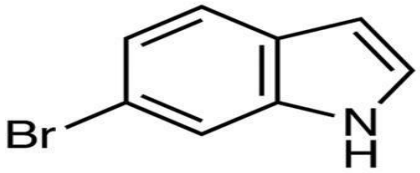
c) Polyhalogenated indoles

d) Polyhalogenated bisindoles

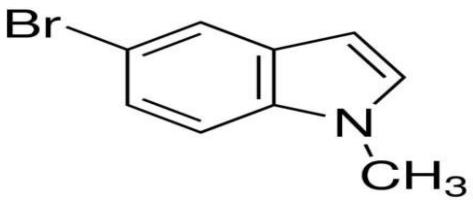
e) Thiomethyl-containing bromobisindoles

STRUCTURE OF HALOGENATED INDOLE:

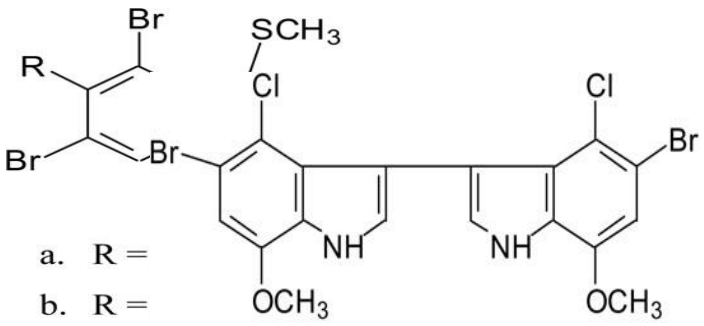
a) Bromoindole



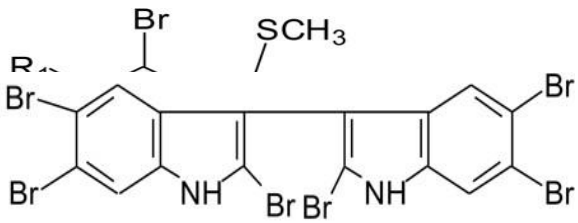
b) N-Methylbromoindole



(c) Sulfur containing bromo alkaloids



a



b

(d) Polyhalogenated bisindoles

(e) Thiomethyl containing bromobisindoles

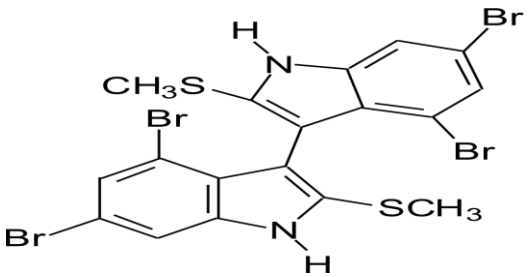
4. OTHERS

LOPHOCLADINES (LO)

There are two derivatives: lophocladine A and lophocladine B which were isolated from a red alga lophocladia species obtained from New Zealand.

1. Lophocladines A (LO A, 4-phenyl-[2,7]-naphthyridine-1(2H)-one)

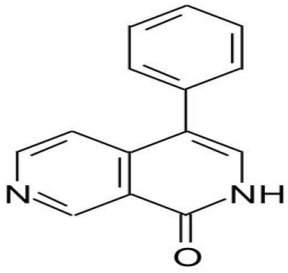
2. Lophocladines B (LO B, 4-phenyl-[2,7]-naphtyridine-1-amine)



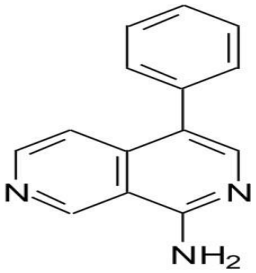
PHARMACOLOGICAL ACTIVITY:

Lung cancer, neuro-2a neuroblastoma and breast cancer lines were used to study the cytotoxic effects of LO A and B.

STRUCTURE OF LOPHOCLADINES [17].



LO A



LO B

LIPIDS FROM MARINE ALGAE

These living things are a well-known source of lipids with significant nutritional value and bioactive characteristics. Seaweeds or macroalgae belong to three distinct phyla: Chlorophyta (green algae), Ochrophyta (brown algae) and Rodophyta (red algae). Macroalgae are less varied than microalgae. In recent times there has been an increasing interest among scientists regarding the lipids found in macroalgae. This is probably due to the notable expansion of seaweed farming on a global scale. In fact, there is growing recognition of the potential of these "blue foods" to improve global food security [18].

The primary transporters of n-3 fatty acids or PUFAs are polar lipids, which have also been shown to have anti-inflammatory, antioxidant, anti-microbial and anti-proliferative qualities [19].

IRON FROM MARINE ALGAE

With iron making up around 35% of the earth's mass, it is one of the four elements that are most common place. In the bodies of living things, iron is also a necessary element, particularly in auto-phototrophic organisms like plants and algae. Numerous enzymes, including cytochrome oxidase, catalase, peroxidase and nitrogenase depend on it as a cofactor. These enzymes are involved in nitrogen fixation, photosynthesis and respiration - three biological activities that require a lot of iron. While it was demonstrated that the electron transport system connected to photosystems needs almost 22 iron atoms, each nitrogenase complex requires 38 iron atoms. Despite iron's abundance, oxidation to the insoluble ferric state limits its bioavailability.

Because they are soluble, ferrous ions are the iron that is most bioavailable in biological systems. Sadly, they are easily oxidized into insoluble ferric ions due to their instability. Surface water concentrations of unchelated iron that are picomolar or nanomolar include the most accessible forms of iron [20].

ALGAL-IRON RELATIONSHIP:

The estimated minimal iron requirements for algae are approximately 3 umol/mol, while for dividing algae, the value is closer to 1-2 umol/mol for Fe/C. The lowest algal iron demand is predicted to be ~1.5 umol/mol for the Fe:C ratio; if the algae are grown on nitrate rather than ammonium, this requirement will increase. Even more iron is needed for cyanobacteria to fix nitrogen. Consequently, algae either increase their iron intake or lower their requirement for iron in order to cope with the extremely low iron concentration in the upper surface water, which is typically in the range of 0.5–1 nM [21].

ROLE OF FERRITIN AS STORAGE FROM OF IRON IN MARINE ALGAE (IRON; HOMEOSTASIS)

Different tactics are used by marine algae to adapt to low iron concentrations. In the coastal California upwelling region, the day/night cycle has a strong regulatory effect on the iron store protein ferritin. Twining and Baines claim that cross-membrane transporter downregulation is the primary mechanism by which cells control intracellular iron contents. Iron is stored as ferritin, nevertheless, when the internal metal content rises far over what is required to support maximum growth. Ferritin is a protein found in many types of bacteria, plants, algae and animals that is specifically designed to store iron.

In situations where the body's supply of iron is restricted, it functions as an iron-concentrating protein and provides iron to the body. It controls iron levels as well. Iron oxidation in Pseudo-nitzschia multiseries ferritin is dependent on glutamate residue, which shifts the iron's role from storage to oxidation. Ferritin an iron-concentrating protein from the Pseudo-nitzschia multiseries, was found to have a ferroxidase binding-iron activity by structural and functional investigation. It must be directed toward the chloroplast in order to regulate the storage and distribution of iron necessary for the healthy operation of photosynthesis [22].

PROTEINS FROM MARINE ALGAE

As a cutting-edge and powerful source of plant-based protein, algae are very desirable for the creation of vegetarian and vegan diets. However, for the extraction and purification of algal proteins to be a long-term feasible solution, improvement of these processes is required. Ultrasound aided extraction or UAE, uses water or other ecologically friendly solvents to extract proteins from algae. In terms of duration and temperature conditions, extraction typically took place at low temperatures for one to two hours. Comparing UAE to the other four employed techniques - alkali, enzymatic, thermal and microwave-assisted extraction (MAE) - it resulted in the highest recovery of proteins (84%) from algal sources. UAE was carried out at room temperature for 60 minutes and used water as the solvent. The utilization of the sugaring out technique in conjunction with UAE resulted in remarkable protein extraction yields of 93.33% on a laboratory scale and 92.24% on a large scale. The ideal conditions for this process were 0.6% biomass concentration, 200 g/L glucose, 100% acetonitrile, 5 minutes of 5 s ON/10 s OFF pulse mode, and 100 mL/min flow rate [23].

CARBOHYDRATES FROM MARINE ALGAE

Algae are high in carbs, with concentrations of up to 75% w/w. Carbs come in a number of forms and can be classified as polysaccharides, alcohols (like butanol) and organic acids (like succinic and lactic acid). Due to their unique composition, seaweeds and microalgae are excellent choices for the extraction and purification of a variety of molecules. This suggests that they have a great deal of potential for use in a variety of biomedical applications, such as the creation of polysaccharides like BCs, which have anti-inflammatory, anti-cancer, anti-coagulant, immunomodulatory, antinociceptive, antimicrobial, hypolipidemic and antidiabetic properties as well as the development of biomaterials for medication delivery, tissue regeneration, surgical glues, lubricants and nanofibers [24].

PIGMENTS FROM MARINE ALGAE

Algae have a wide range of pigments, including phycobilins, carotenoids and chlorophylls, which account for their varied hue. Certain algae species such as *Spirulina species*, *Porphyra species*, *Laminaria ochroleuca*, *Undaria pinnatifida*, and *Himanthalia elongata* are regarded as rich sources of colors. Each type of pigment has a different solubility because of variations in its polarity. Therefore, selecting the right solvent is essential to maximize their extraction. Accordingly it has been shown in multiple studies that ethanol is a highly effective solvent for the extraction of carotenoids and chlorophylls, whereas phosphate buffer is typically used for the extraction of phycobiliproteins [25].

PHENOLIC COMPOUNDS FROM MARINE ALGAE

As well-established BCs, phenolic compounds are significant secondary metabolites found in both algae and plants. They have been shown to have anti-inflammatory, anticancer and antioxidant properties. Three categories comprise the majority of algal sources: flavonoids, phenylpropanoids and phenolic acids. It has been suggested that extracting phenolic compounds from algal sources is a promising approach with ultrasound assisted extraction (UAE) serving as the effective industrial technology. Nevertheless, the ideal circumstances differ greatly according on the species, therefore they must be carefully considered. According to the nature of phenolic compounds, in addition to the widely distributed phenolics like flavonoids and phenolic acids, algae also biosynthesize particular phenolic compounds known as phlorotannins, which are almost exclusively found in brown algae and have gained a lot of attention recently because of their potential medical uses. Numerous investigations have been carried out to evaluate the existence of these substances in various brown algae species, and a few of them have selected the United Arab Emirates as a means of recuperation [26, 27].

MICRONUTRIENTS FROM MARINE ALGAE

Algae are thought to be an abundant source of oligo-elements, mineral salts and vitamins. Algae are high in vitamins A, B1, B12, C, D and E as well as riboflavin, niacin, pantothanic acid and folic acid all of which are hydrosoluble and liposoluble in varying amounts. For example spirulina is frequently taken by anemic individuals to prevent iron shortage as well as vitamin B12 and E deficiency. *Sargassum polycystum*, *Eucheuma cottonii* and *Caulerpa lentillifera* have ~0.035 mg/g of vitamin C and 0.006–0.0113 mg/g of vitamin E.

Seaweeds have a mineral composition of up to 36% dry weight, with the most common minerals being Na, Ca, Mg, K, Cl, S and P. The distribution of these minerals varies depending on the species and is influenced by the family of algae in which they are found. For instance, different species of seaweeds in the Caulerpaceae family have similar mineral compositions, yet they consistently follow the same general pattern: Na > K > Ca > Mg. Conversely, microalgae have greater concentrations of trace minerals such I, Cu, Se, Mo, F, Mn, B, Ni, and Co, as well as Na, K, Ca, Mg, Fe, and Zn [28].

CULTIVATION OF ALGAE: MICROALGAE

The organisms that comprise phytoplankton known as microalgae include autotrophs, microflagellates and microciliates. Fish crustaceans and mollusks benefit greatly from the high nutritional content these species offer. They are also very useful for making agar and carrageenan as well as managing culture systems managing culture systems in lab settings. The primary goal of microalgae cultivation is often to get species in a controlled environment. Increasing their population for commercial, industrial and ecological reasons is another cause. Other motivations include researching their traits and ways of life and figuring out the best environments in which to raise them. They are thought to have a great deal of promise, particularly in the commercial, industrial, technological and pharmaceutical sectors.

ALGAE CULTURE IN LABORATORIES

One particular purpose of the algae cultures kept in labs is to learn and explore every aspect of a single species. The benefits are similar to those of studying them in a solitary setting in this regard. Laboratory experiments facilitate a greater understanding of the ideal conditions for large-scale production, with implications for both commercial and technological applications. As a result, they also aid in maximizing the population expansion of the investigated algae. The ability to investigate the intricate relationships between these species and the best conditions for their reproduction is made possible by the laboratory culture of these species. This includes the following: temperature, pH, light intensity, rate of aeration, and nutrient concentration. These are the prerequisites that guarantee the production of large-scale crops, with the required resources and without causing appreciable losses. Laboratory – developed growth models serve as a kind of planning tool that facilitates the construction and operation of photobioreactors or large-scale algal cultures at optimal efficiency [29].

ALGAL CULTIVATION: MACRO ALGAE

Worldwide, macroalgae are collected with China and Japan hosting the biggest concentrations. In addition to their excellent nutritional worth the majority of them are used in various industrial operations. Eastern nations consume a lot of them. They are mostly utilized as fertilizers, animal feed and/or food additives throughout the remainder of the world.

MACROALGAE CULTIVATING IN A SALTWATER AQUARIUM

Certain types of macroalgae are grown by many saltwater aquarists in their main tanks, refugiums and sump pumps. Many marine aquarists have discovered that cultivating their own macroalgae is an excellent method to provide their tank creatures with this affordable natural food. Macroalgae is a major food source for many fish and invertebrates in the oceans. The term "good kind of algae" refers to macroalgae rather than microalgae (hair algae, for example). Many macroalgae species have proven to be quite beneficial to saltwater aquarists' systems, serving as food for herbivores and lowering phosphate (PO4) and nitrate (NO3) levels in the aquariums. Certain fish and invertebrates housed in marine aquariums primarily eat copepods and amphipods, which can be found in abundance on certain types of macroalgae.

PURPOSE OF MACROALGAE

Three goals are served by macroalgae grown in marine aquariums: they are decorative, reduce nitrogen levels (NO3, PO4) and provide food for fish and invertebrates.

PHOSPHATE AND NITRATE REDUCES MACROALGAE

- Penicillus sp., or shaving brush algae
- Will gain form the regular administration of trace elements and an iron supplement.
- Aids in removing phosphate (PO4) and nitrate (NO3) from the water column.
- Chaetomorpha sp., or spaghetti algae

- Many herbivorous species find this algae unpalatable, despite its rapid growth.
- Regular pruning is required to stop the rapid die-off that occurs during sexual reproduction and contaminate the tank.
- Comes in a range of shapes such as grape-shaped, feather-bladed, notch-leaf and flat blades.

DIETARY MACROALGAE

- Penicillus sp., or shaving brush plant
- Will gain from the regular administration of trace elements and an iron supplement.
- Can significantly aid in lowering the levels of phosphate and nitrate in the water column.
- Algae from Halmeda (Halimedasp.)
- Is intolerant of elevated NO3 or PO4.
- Needs calcium.
- Is intolerant of heavy pruning.
- Smooth Leaf, Kelpon Rock (Haliptilonsp.)
- The hue might range from deep crimson to a dark pink.
- Low-nutrient vegetation.
- Works best in illumination that is moderate to strong.
- A refugium is a better growing environment than the main tank.

CHLORODESMIS (HAIR OF MAIDENS)

- Excellent habitat for copepods and amphipods to breed.
- Is poisonous, discouraging herbivorous fish from consuming it.

FAN OF MERMAID (UDOTEA SPECIES)

- Is intolerant of elevated NO3 or PO4.
- Needs calcium

CAULERPA

- They come in a variety of shapes, such as grape-shaped, feather-bladed, flat-bladed and notch-leaf varieties.
- Regular pruning is necessary to avoid a quick die-off that occurs during sexual reproduction and contaminates the tank.

NUTRIENTS FOR MACROALGAE

- For certain algae to thrive, phosphate and nitrate are necessary.
- Certain algae cannot withstand elevated phosphate or nitrate levels.
- Supplements of calcium are necessary for calcareous macroalgae, such as Halimeda.

• Certain macroalgae, including Shaving Brush, get advantages from the consistent addition of trace elements and an iron supplement.

MACROALGAE GROWING

The selection of macroalgae species is primarily influenced by two factors.
For the most part, macroalgae need medium-to-strong illumination to grow. The macroalgae's color can change in response to variations in light intensity. We should often check the water quality in our aquarium because certain macroalgae have the ability to alter the pH of the water through their respiration. When exposed to light, they produce oxygen; when exposed to low light, they absorb oxygen and produce carbon dioxide, which lowers the pH of the water. Make cuttings from a large sample of a macroalgae and use super glue to adhere it to a shell, live rock or coral skeleton (pay particular attention to the holdfast, if the algae has one). Put these fresh cuttings in an aquarium with enough lighting, water circulation and water quality. An aquarist should be aware that macroalgae can reproduce sexually, sending spores into the water that can increase the levels of phosphate and nitrate. The algae will most likely be encouraged to reproduce sexually and release spores if the water quality is poor [30].

PHARMACOLOGICAL ACTIVITY OF MARINE ALGAE

Anti-bacterial activity

Historically, algae have been utilized for food or to make hydrocolloids like carrageenan and alginate. Modern screening techniques, however, have found antibacterial chemicals in algae groups' secondary metabolites, including the brown Phaeophyceae, red Rhodophyceae, green Chlorophyceae, golden Chrysophyceae and diatom-like Bacillariophyceae. Phlorotannins, fatty acids, polysaccharides, peptides, terpenes, polyacetylenes, sterols, indole alkaloids, aromatic organic acids, shikimic acid, polyketides, hydroquinones, alcohols, aldehydes, ketones and halogenated furanones, alkanes and alkenes are among the functional groups in these compounds that exhibit antibacterial activity. Algae are subjected to extremes in salinity, oxygen, UV radiation and osmotic stress. Furthermore, each milliliter of seawater has one million bacterial cells on average. Due to the harsh environment in which they live and the diluting influence of seawater, algae produce compounds that have the potential to be antibacterial, and many of these molecules have significant biological activity [31].

Anti-oxidant activity

Marine algae generate a wide range of substances that serve as chemical defense mechanisms and help them survive in harshly competitive situations. Over the course of the last 40 years, studies into the chemistry of natural products and the chemical defenses of algae have led to the isolation of over 15,000 new compounds, many of which have been demonstrated to have bioactive qualities. Compounds with different bioactivities are produced by algae belonging to the three groups that are commonly referred to as Chlorophyta (green algae), Rhodophyta (red algae) and Phaeophyta (brown algae). Free radicals and other reactive oxygen species (ROS) can easily develop when ultraviolet radiation and air are combined with marine algae in shallow water environments. Healthy algae resist oxidation during storage and do not exhibit oxidative damage to their structural components (fatty acids) while being exposed to damaging ROS, suggesting the presence of beneficial antioxidant defense systems in their cells. Antioxidants neutralize free radicals by giving up an electron, which prevents them from oxidizing biomolecules and causing tissue damage and cell death. As a result, the amount of naturally occurring antioxidants derived from algae has grown recently. The ultimate goal of this kind of research is to identify substances and/or extracts that can inhibit oxidative stress processes, including those caused by free radicals, and so lower the frequency of diseases in humans that are directly associated with these processes. Many marine algae genera, such as *Ahnfeltiopsis*, *Colpomenia*, *Gracilaria*, *Halymenia*, *Hydroclathrus*, *Laurencia*, *Padina*, *Polysiphonia* and *Turbinaria* have been shown to exhibit antioxidant activity. Algae-derived natural antioxidants are well known for their significant anti-aging and disease-preventing properties. These and other genera' algae have been shown to contain antioxidant chemicals that may have anti-aging, nutritional, anti-inflammatory, antibacterial, antifungal, cytotoxic, anti-malarial, antiproliferative and anticancer effects. antioxidant activity of several genera of algae, many of which are frequently found in the Hawaiian Islands; nevertheless, there are no reports of systematic studies to determine the antioxidant activity of Hawaiian algae species. Within the there are over 520 species of marine algae in the Hawaiian Islands, but very few of them have undergone any kind of biochemical research. 22 species of Hawaiian algae were tested for their protein, lipid, carbohydrate, ash, calorie, mineral, and vitamin contents to determine their nutritional makeup. Antimicrobial activity was also demonstrated by these algal extracts. Considering the possible industrial applications of algae antioxidant molecules in the food, pharmaceutical, cosmetic and medical sectors [32].

Anti-thrombotic and Anti-coagulant activity

Fucoidans and other fucans of brown seaweeds display heparin-like anticoagulant activity, which is the bioactivity of marine sulfated polysaccharides. Springer and colleagues originally reported this for fucoidan that was isolated from *F.vesiculosus*, and they discovered that it inhibited the development of fibrin clots and had antithrombin activity.

Although the exact mechanism of action behind these activities is unknown, several studies point to multiple mechanisms of action, including direct and indirect thrombin inhibition through the activation of thrombin inhibitors (such as antithrombin and heparin cofactor II). Human plasma's clotting time was extended by the fucans from ten different brown seaweeds. Only five of these fucans, nevertheless, demonstrated appreciable resistance to thrombin-induced platelet aggregation. certain fucans' direct interaction with thrombin, which prevents thrombin from attaching to platelet receptors. The general structural characteristics of fucans, such as their molecular weight, sulfation level and the location of sulfate groups on the sugar backbone are crucial to their anticoagulant activity. For instance, Nishino and coworkers discovered that in sulfated polysaccharide fractions from *E.kurome*, larger levels of fucose and sulfate groups correlated with higher levels of anticoagulant activity. Additionally, they demonstrated that the anticoagulant activity of fucans positively linked with the amount of sulfate present and that the only fucans that exhibited substantial activity were those with a sulfate-total sugar residue ratio larger than one. Fucans with a higher molecular weight have a stronger anticoagulant effect than those with a lower molecular weight. Sulfated fucan needed far longer chains than mammalian glycosaminoglycans to acquire anticoagulant activity, and the connection between the molecular weight of sulfated polysaccharides and their anticoagulant activity was similarly thought to be linear. The impact of selective cleavage to significantly lessen the fucan's molecular size significantly diminished the thrombin inactivation caused by heparin cofactor II. In contrast to native fucan, lower molecular weight fucans did not successfully promote the heparin cofactor II association with thrombin, while appearing to bind to heparin cofactor II. The position of the sulfate group on sugar residues is important for anticoagulant action. It has been demonstrated that marine sulfated polysaccharides other than fucans have anticoagulant properties. Sulfated polysaccharides resembling ulvan and galactan that are derived from green algae, specifically Codium and Ulva species. One sulphated polysaccharide from *U.conglobata* that appeared to directly block thrombin and modulate heparin cofactor II was found to have a high rhamnose content and a 35% sulfate ester, hence prolonging the clotting time. A high rhamnose-containing sulphated polysaccharide from *Monostroma nitidum* was shown to have greater anticoagulant action than conventional heparin when sulphated polysaccharides from 23 different species of green algae were tested. Additionally, red seaweeds have produced several sulphated polysaccharides with strong anticoagulant properties [33].

Anti-hypertensive activity

A counteraction to hypertension cardiovascular diseases (CVDs) pose a significant risk to a large number of lives worldwide and usually result in health complications. The best combination of lifestyle changes and diet therapy to lower blood pressure is ideal. As a result, ACE-I inhibitors from natural sources expand the range of potential dietary combinations. The renin-angiotensin-aldosterone system (RAAS) is a key player in blood volume regulation and is in charge of maintaining fluid balance and blood pressure in humans. The monomeric, membrane-bound zinc metalloprotease known as angiotensin-I-converting enzyme (ACE-I) catalyzes the transformation of the decapeptide angiotensin-I into the octapeptide angiotensin-II by eliminating the carboxyl-terminal dipeptide. One well-known strong vasoconstrictive chemical is angiotensin-II. Consequently, it has long been known that ACE-I play a crucial role in the rennin-angiotensin system (RAS), which controls blood pressure. Therefore, the best method for treating hypertension is to use ACE-I inhibitory factor. According to Verdecchia, Angeli, Mazzotta, Gentile and Reboldi (2008), there are two approaches to inhibit RAS: either by blocking ACE-I to prevent angiotensin-II from being converted from angiotensin-I or by directly inhibiting the formation of angiotensin-I from angiotensinogen. Renin catalyzes the first and limiting step of the RAS and is thus regarded as a monospecific enzyme. It also exhibits extraordinary sensitivity towards angiotensinogen. Renin inhibitors, thus, have a beneficial impact that provides for the blockage of this intricate hormonal system at the point of first activation. But recently, aliskiren, a new direct renin inhibitor, has made progress. When taken orally, the non-peptide Aliskiren has a low molecular weight and successfully decreases blood pressure in people with mild to moderate hypertension when taken once daily.

Furthermore, a lot of synthetic chemical medications, including lisinopril, captopril, enalapril and alacepril have been used to treat and prevent hypertension. However, these artificial ACE inhibitors have unfavourable side effects that include angioneurotic edema, chronic dry cough, taste loss and renal impairment [34].

Anti-cancer activity

Among all the algae, marine macroalgae are the most fascinating due to their
wide range of biological actions including antioxidant, antimicrobial, antiviral, antifungal, antiallergic, anticoagulant and anticancer properties. In their environment, they generate a diverse range of chemically active metabolites. Many chemical compounds with a wide range of biological activity that are obtained from macroalgae have been employed in the pharmaceutical industry. Antibiotic compounds that can suppress bacteria, viruses, fungus and other pibionts are produced by a large number of marine algae. It seems

that a variety of elements, such as the specific alga, the bacteria, the season and the growth conditions, influence the antibiotic property. Some marine algae have antibiotic properties because of a number of extractable chemicals that are harmful to bacteria, including halogenated compounds and cyclic polysulfides. Organic materials from young red algal forms, Chondrus crispus, inhibited the growth of nearby diatoms [35].

Anti-viral activity

Some synthetic antiviral medications were created in response to the problems of this virus in order to treat acute herpetic infections; however, they are ineffective in treating latent infections. However, the negative side effects and the emergence of some resistance mutations in this virus, particularly when taking antiviral medicine for an extended period of time. Innovative antiviral medications, some plant and algal extracts were examined using a variety of viruses, including herpes viruses. Several brown algal species were examined for their antiviral properties in some of these investigations. Deig and colleagues revealed that extracts form a number of marine algae species that were gathered from the California coast had antiviral qualities [36].

Anti-neuroinflammation activity

The immune cells in the central nervous system or microglia are involved in immunological surveillance. They are derived from the blood circulation and enter the system early in an organism's development. The way that microglia control the release of inflammatory responses may have significant therapeutic promise for the management of neurodegenerative illnesses. The "sea trumpet," *Ecklonia cava* (Phaeophyceae; Laminareaceae), has been shown to have anti-inflammatory properties. By preventing nuclear factor-κB (NF-κB) and mitogen-activated protein kinases (MAPKs) from activating, *E.cava* was able to suppress the levels of pro-inflammatory mediators in lipopolysaccharides (LPS)-stimulated BV2 cells, including nitric oxide, prostagladine-E2 and pro-inflammatory cytokines, interleukin-6 and interleukin-1β. Sea algae can reduce pro-inflammatory mediators in microglia suggests that they may have neuroprotective properties. Additionally, there is a lot of potential use for marine algae as anti-neuroinflammatory drugs in the food industry as well as the medicinal sector. The use of marine algae in medications and functional meals has many benefits, including low production costs, minimal cytotoxicity, safety and broad acceptance [37].

Anti-neurotoxicity activity

Neurotoxins are a broad category of substances that interfere with nerve impulse transmission to cause very precise effects on the neurological systems of animals, including humans. When given either in vivo or in vitro, they have the potential to cause neurodegeneration or damage to neurons. For instance, β-amyloid (Aβ) peptides have been shown to have a neurotoxic effect on glial and neuronal cells. In an animal model of Parkinsonism and dopaminergic cells, fumoidan extracted from *L.japonica* was able to protect against 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP)-induced neurotoxicity. The antioxidative activity of fucoidan may have a role in the protective mechanisms it offers. In GT1-7 cells, it has been demonstrated that *H.incrassata* and *B.triquetrum*, at a concentration of 0.2 mg/mL, protect against methyl mercury-induced neurotoxicity. When combined, marine algae and their bioactive components can be used to create novel therapeutic medicines that protect the central nervous system from neurotoxins [38].

The inhibitory activity of cholinesterase Alzheimer's disease (AD) is a neurological illness that progresses irreversibly and causes memory loss, behavioral issues, personality changes and a reduction in cognitive function. Thus, acetylcholine (ACh), a neurotransmitter in the brain, was linked to deficiencies in AD. One of the more practical methods for treating AD symptoms could be to suppress the acetylcholinesterase (AChE) enzyme, which catalyzes the breakdown of ACh. AChE inhibitory action of various marine algae species has been demonstrated in a number of recent researches. The marine algae listed below have been shown to exhibit strong AChE inhibitory action [39].

Acetylcholinesterase inhibitory activity

Additionally, *Ecklonia stolonifera* extracts demonstrated a strong inhibitory action on AChE, as determined by ethanolic extracts of 27 marine algae from Korea. From *E.stolonifera*, two sterols and eight phlorotannins were recovered. While eckstolonol and phlorofucofuroeckol-A showed inhibitory activity against both AChE and butyrylcholinesterase (BChE), eckol, dieckol, 2-phloroeckol, and 7-phloroeckol indicated selective dose-dependent inhibitory actions toward AChE.

Marine algae	Extracts/Compounds	IC50
Caulerpa racemosa	MeOH extracts	5.5 mg mL−1
Codium capitatum	MeOH extracts	7.8 mg mL−1
Ulva fasciata	MeOH extracts	4.8 mg mL−1
Halimeda cuneata	MeOH extracts	5.7 mg mL−1
Amphiora ephedraea	MeOH extracts	5.1 mg mL−1
Dictyota humifusa	MeOH extracts	4.8 mg mL−1
Hypnea valentiae	MeOH extracts	2.6 mg mL−1
Padina gymnospora	MeOH extracts	3.5 mg mL−1
Ulva reticulate	MeOH extracts	10 mg mL−1
Gracilaria edulis	MeOH extracts	3 mg mL−1
Ecklonia stolonifera	EtOH extracts	108.11 µg mL−1
Ecklonia stolonifera	Eckstolonol	42.66 µM
Ecklonia stolonifera	Eckol	20.56 µM
Ecklonia stolonifera	Dieckol	17.11 µM
Ecklonia stolonifera	2−phloroeckol	38.13 µM
Ecklonia stolonifera	7−phloroeckol	21.11 µM
Ishige okamurae	MeOH extracts	163.07 µM
Ishige okamurae	EtOAc extracts	137.25 µM

Furthermore, it has been observed that two marine algae species from Tamil Nadu, India, Hypnea valentiae and Ulva reticulate, suppress both AChE and BChE activity. When combined marine red, brown and green algae can effectively decrease ChE activity, which makes them viable candidates for usage as functional neuroprotective drugs. Certain substances obtained from marine algae have been shown to have mixed type ChE (AChE and BChE) inhibitory actions, which are thought to be more beneficial in the treatment of AD [40].

Inhibition of neuronal death

The abnormal loss of specific neuronal subsets is a frequent feature of many neurodegenerative disorders. Necrosis and apoptosis are two types of neural cell death that can result in neurodegeneration of certain neuronal subgroups. An isolated fucoidan from *Fucus vesiculosus* was found to be able to prevent Aβ-induced cholinergic neuronal death in rats. The pre-treatment with fucoidan inhibited the activation of both caspase-3 and caspase-9. Caspase-3 and Caspase-9 inhibit the production of free radicals [41].

Other neuroprotective activity

A basic characteristic of neurons, neurite outgrowth is crucial to the development of neurons in the developing embryo and adult brain. In rat pheochromocytoma (PC12) cells, sargaquinoic acid and sargachromechanol two of the plant's active constituents, have been demonstrated to stimulate neurite outgrowth. The structural component of sargaquinoic acid, quinone, is what gives the molecule its neurite outgrowth-promoting properties. The neuritogenic activity was significantly impacted by the hydroxyl group attached to quinone. Additionally, phenophytin A, a molecule linked to chlorophyll and its analogue, vitamin B12, which is generated from *Sargassum fulvellum*, may have the ability to promote neurite development. *Eisenia bicyclis*-derived phenoltannins have been shown to decrease the activity of the β-amyloid cleavage enzyme (BACE-1). Because it starts the production of Aβ, BACE-1 is a potential biomarker for AD. Under fucoidan therapy, there was an Aβ-induced increase in human neuroblastoma cell proliferation [42].

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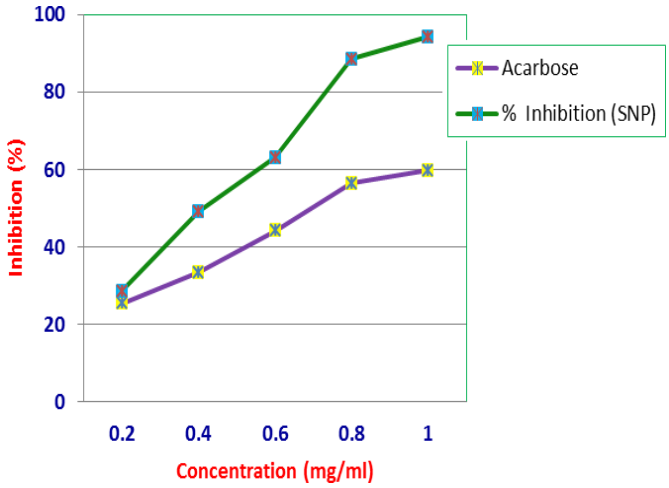
Anti-diabetic activity

About 3% of people worldwide suffer from diabetes mellitus, a metabolic disorder marked by hyperglycemia brought on by abnormalities in insulin secretion, action or both. Long-term glucose poisoning can cause consequences such chronic renal failure, retinal impairment and neurological and cardiovascular illnesses. The breakdown of starch and oligosaccharides into glucose is facilitated by the enzymes glucosidase and amylase, which, if inhibited, would postpone the intestinal absorption of glucose. The postprandial blood sugar is eventually brought under control. The special qualities and uses of silver nanoparticles have been applied to biosensing, chemical sensing, photonics, biosensing, electronics, pharmaceuticals and biomedicine, particularly for antiviral and antibacterial agents. As a result, the antidiabetic activity of silver nanoparticles derived from the marine brown alga *Colpomenia sinuosa* can be expanded.

Silver nanoparticles are used in the medical field as topical ointments to stop burns and open wounds from becoming infected. The antidiabetic potential of silver nanoparticles that were biosynthesized from the marine brown alga *Colpomenia sinuosa* was examined in this work. There are a number of ways that algae can regulate blood glucose levels. One such mechanism is the inhibition of alpha amylase and alpha glucosidase activity, which would postpone the breakdown of carbohydrates and reduce glucose absorption as a consequence of postprandial blood glucose increase [43].

In vitro anti diabetic activity from *colpomenia sinuosa*

S.No	Concentration of Sample (mg/ml)	Acarbose	% of inhibition of silver nanoparticles
1.	0.2	25.39 ± 0.01a	28.70 ± 0.10a
2.	0.4	33.35 ± 0.01b	49.30 ± 0.10b
3.	0.6	44.15 ± 0.01c	63.20 ± 0.10c
4.	0.8	56.35 ± 0.01d	88.50 ± 0.10d
5.	1	59.69 ± 0.10e	94.30 ± 0.10e
6.	F-Value P-Value	0.00000508 0.0000223	0.000 0.000
7.	IC50	630 ± 0.01 mg/ml	480 ± 0.10 mg/ml



In vitro Anti diabetic activity of alpha amylase

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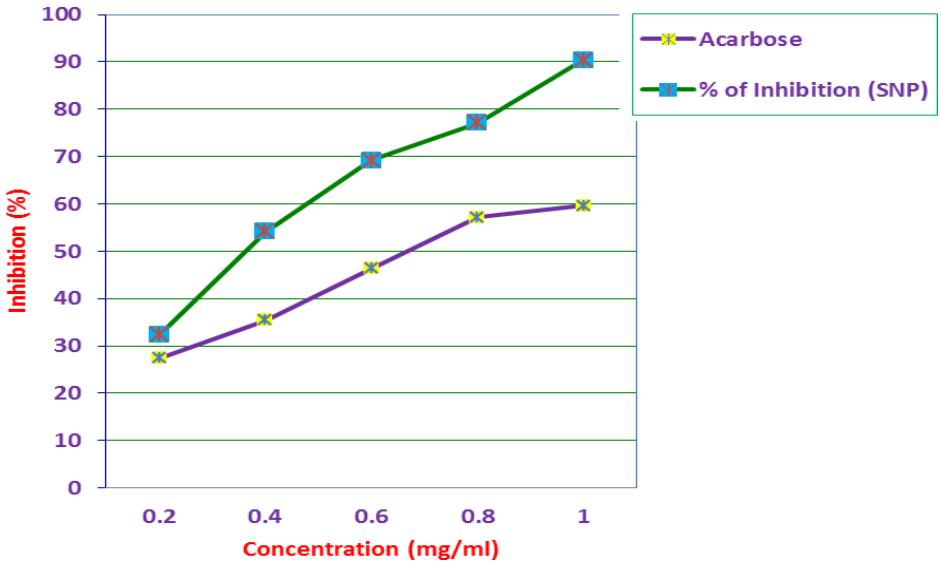
Invitro anti diabetic activity of alpha glucosidase

S.no	Concentration of sample mg/ml	Acarbose	% of inhibition of silver nanoparticles
1	0.2	27.37±0.01a	32.40±0.10a
2	0.4	35.43±0.01b	54.20±0.10b
3	0.6	46.33±0.01c	69.30±0.10c
4	0.8	57.13±0.01d	77.20±0.10d
5	1	59.63±0.01e	90.50±0.10e
6	FValue Value	0.00000574 0.000	0.0000149 0.000
7	IC 50	695±0.01mg/ml	370±0.10mg/ml



BIOACTIVITES OF THE GENUS *GRACILARIA* FROM MARINE ALGAE

Studies of toxicity

Studies on extracts using ethanol and water extracted from the dried whole plant of *G.foliifera* revealed cytotoxicity and toxicity in humans when administered orally. Additionally, harmful to humans were *G.edulis* and *G.coronopifolia*. In the *G.gracilaria* substances such as carbohydrates, heparin, agar, manauealides A, B and C, as well as palmitic, palmitoleic, oleic, lauric and myristic acids, steroids and alkaloids malyngamide, were discovered. *G.foliifera*, *G.coronopifolia* and *G.edulis* compound structures. A quick and efficient way to accomplish primary toxicity and biological activity screening of chemicals is to use the *Artemia salina L.* brine shrimp assay to estimate the 50% lethal concentration (LC50). The LC50 of a 90% ethanol extract of *G.domingensis* against *A.salina* was 200 µg/mL. Determining the cytotoxic activity is another way to assess toxicity. In this instance, the ethanol extract from *G.verrucosa*, the chloroform and methanol extracts from *G.textorii*, which was separated to produce the steroid cholest-4-en-3-one, and the aqueous extract from the dried thallus of *G.bursa-pastoris* (10.0 µg/mL) were not harmful in cell culture. Mice, however, were poisonous to *G.verrucosa* aqueous extract at a level of 1.2 mg/animal. Lipids include PGFα, glycerol, ethanolamine-phosphatidyl, choline-phosphatidyl, ethanol-phosphatidyl and floridoside were identified in this seaweed along with polysaccharides like agar [44].

Effects on the nervous system

Research on the nerve system is crucial for comprehending and managing intricate behavioural and degenerative illnesses. 90 percent ethanol extracts from *G.edulis*, *G.corticata* and *G.verrucosa*, at 50mg/kg did not exhibit any analgesic or anticonvulsant effects in mice, nor did it have any peripheral or central effects in dogs [45].

Contraception activity

Along with looking into novel compounds with anticonceptive properties, the researchers also assessed marine seaweeds ability to prevent pregnancy in animals after coitus. From the first to the seventh day of their pregnancies, female rats were given 500 or 1000 mg/kg/day of an oral methanol:methylene chloride (1:1) extract from *G.corticata*. Increased pre-implantation caused by higher doses resulted in notable post-coital contraceptive effectiveness without appreciable side effects. These results suggest that red marine algae may contain post-coital contraceptive medications. 90% of the ethanol extracts from *G.corticata* and *G.edulis* (100 mg/kg) were rendered inactive prior to their antiimplantation impact in pregnant rats. In spermicidal bioassays, ethanol extracts from the shade-dried thallus of *G.edulis* and *G.verrucosa* showed little activity. Sperm motility was completely inhibited by *G.edulis* extracts, and this result was linked to spermicidal compounds breakdown of the plasma membrane [46].

Anti-inflammatory and anti-oxidant activities

There is an anti-inflammatory effect of the seaweeds. Fractions of polysaccharides from Mice were given *G.verrucosa* orally and intraperitoneally at a dose of 4.0 mg/animal and the bacteria demonstrated immunopotentiating activity via promoting phagocytosis. Antioxidant properties were also observed in *G.verrucosa* polysaccharide fractions and methanol extract.
Collagen, arachidonic acid or adenosine diphosphate-induced platelet aggregation was not inhibited by an aqueous extract from *G.textorii* at a concentration of 100 µg/mL. PGE2, which has physiological effects such as heat, hypotension, smooth muscle dilatation, hyperalgesia and suppression of gastric secretion is found in *G.verrucosa*, *G.asiatica*, *G.lichenoides* and other species [47].

Gastrointestinal effect

Mice with gastrointestinal disorders caused by zeaxanthin and antheraxanthin, carotenoids, pyrimidine 2-amino-4-carboxy, non-alkaloid nitrogen heterocycle, steroids, 5-alpha-poriferastane, 3-beta-6-alpha-diol poriferastane, 5-alpha-3- beta-6-beta-diol and gigatinine were treated with an aqueous extract from dried *G.verrucosa* algae or fresh *G.chorda* algae at a dose of 0.5 mg/animal [48].

Cardiovascular effect

The cardiac effect 90% of dogs treated with 50 mg/kg of ethanol extracts from *G.corticata*, *G.edulis* and *G.verrucosa* did not experience any cardiovascular effects. 90% of the *G.edulis* ethanol extract exhibited diuretic efficacy. Rats received an intravenous aqueous extract from *G.lichenoides* which had antihypertensive effects. Methanol extract from did not cause tyrosinase inhibition. *G.arcuata* and the 10 µg/mL aqueous extract from *G.textorii* had no effect on aldose reductase [49].

Antibiotic activity

Various algal extracts and components have demonstrated antibacterial action against both gram-positive and gram-negative bacteria in vitro. To assess the antibacterial susceptibility, the agar disc diffusion method was employed. 20 µL of the extracts were impregnated onto 6 mm discs, which were then inserted into Muller Hinton agar that had been inoculated. *G.edulis* (Gmelin) Silva's chloroform extract was examined for its antibacterial properties against strains of *Salmonella paratyphi*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*, *Vibrio cholera* and *Staphylococcus aureus*. *G.edulis* extract has more action than *S.aureus* extract. Algal organic extracts effectiveness against microorganisms that are resistant to multiple antibiotics. *G.debilis* ethanol extract was inert against *Mycobacterium smegmatis* but exhibited antibiotic action against *S.aureus*. At a dosage of 5.0 mg/mL, a 95% ethanol extract from whole dried *G.cervicornis* algae demonstrated antibacterial activity against *S.aureus*. Fresh *G.corticata* was found to have active methanol extract against *S.aureus*, *Bacillus subtilis*, *Bacillus megaterium* and *Streptococcus viridians*. The growth of *Fusarium solani*, *Penicillium funiculosum*, *Aspergillus niger* and *Alternaria solani* was not inhibited by *G.corticata* or *G.pygmea*. Extracts of this seaweed in petroleum ether, chloroform and methanol at a concentration of 1.0 µg/units were shown to have no effect on the inhibition of the penicillinase enzyme. *G.domigensis* and *G.sjoestedii* ethanol extracts demonstrated antibacterial activity against *S.aureus* and *E.coli*. By using the agar plate method, it was demonstrated that ethanol extracts from *G.debilis*, *G.domingensis* and *G.sjoestedii* were effective against *Candida albicans*, but extracts from *G.tikvahiae* in ether, chloroform and methanol were ineffective. Extracts from *G.sjoestedii* and *G.debilisi* did not stop *Neurospora crassa* from growing; however, an ethanol extract from *G.domigensis* proved effective against both *Mycobacterium smegmatis* and *Neurospora crassa* [50].

Anti-viral activity

When tested in cell cultures, extracts from *G.bursa-pastoris* and *Gracilaria sp*. showed no activity against the human immunodeficiency virus (HIV) or the Herpes simplex 1 virus (HSV). From these extracts, citrullinyl-arginine and granin BP proteins were separated. When tested at a concentration of 400 µg/mL, the methanol extract from dried *G.pacifica* was ineffective against

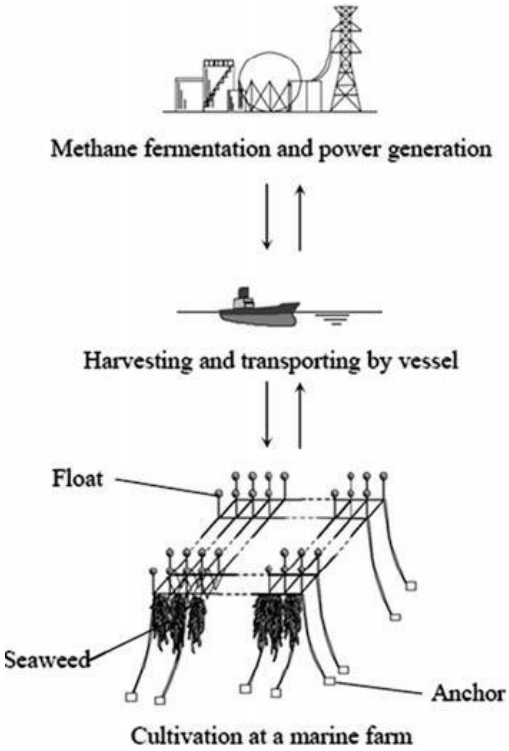
H.simplex 1, however it was efficacious against *Sindbis* virus at 200.0 μg/mL. Compounds and extracts from *Gracilaria sp*. that exhibit anti-HIV action are also effective against HSV and other retroviruses [51].

ALGAL METABOLITES IN FOOD AND COSMETICS

Many marine resources have drawn interest recently as researchers look for bioactive molecules to create novel medications and health meals. Rich in nutritional fiber, minerals and proteins are edible algae. Nowadays, it's thought that marine algae are a great source of antioxidants. Fucoxantine in Hijikia fusiformis and phylopheophytin in Eisenia bicyclis were shown to be two of the active antioxidant chemicals found in brown algae. On the other hand, these algae are often dried, cooked, steamed and stored. After 48 hours of drying at 50 degrees Celsius, the radical scavenging activity of a brown alga called Fucus was reduced by 98%. In addition, before being eaten, these dehydrated goods are soaked in water 20–40 times. Agars are employed in laboratory media culture and the food business. They are extracted from red seaweeds like *Gracilaria*. To add certain gel properties, carrageenans are derived from red seaweeds like *Eucheuma*, *Gymnogongrus* and *Chondrus*, among others. In addition to being a rich source of structurally innovative and physiologically active metabolites, marine algae are also showing significant potential for novel medicinal and industrial applications due to the growing number of metabolites produced by bacteria and fungi [52].

BIOMASS TECHNIQUE FROM MARINE ALGAE

Seaweeds, also referred to as macrophytic marine algae are multicellular, nonvascular, photosynthetic "marine plants" that live in coastal regions of ocean waters. These habitats are either rocky intertidal areas or submerged reef-like environments. With almost 7,000 species combined, brown algae, red algae and green algae are the three main categories of marine macro algae. Because of the intense battle for light, resources, and space in the rocky intertidal marine environment, many marine seaweeds have evolved chemical defense mechanisms to fend off predators and increase their chances of survival.



Cultivation at a marine farm

Howard Wilcox was the first to propose the use of marine biomass as a source of energy in 1968. Up until 1990, government agencies, academic institutions and private companies in the US collaborated on the marine biomass energy initiative. The initiative suggested cultivating gigantic brown kelp or *Macrocystis pyrifera*, a type of brown algae with a high growth rate that can reach lengths of up to 43 meters [53].

At an offshore farm, seaweeds are grown, harvested and then transported by boats. Efficient use of the sea area could yield large amounts of renewable energy. Furthermore, natural seaweeds frequently create underwater forests that function as fish and shellfish habitats. Therefore, if a marine biomass energy system is established, it might increase marine food production and support the marine

energy sector, which would reduce CO2 emissions. However we should re-evaluate the usage of marine biomass energy as a way to offset CO2 emissions now that global warming has emerged as one of the most pressing issues that needs to be resolved [54].

Although marine biomass has received less attention than terrestrial biomass thus far for energy usage, it is currently being recognized as "the third generation biomass" and is seen as a possible alternative renewable source for the development of biofuels [55].

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