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ROLE OF ALGAE IN COSMETICS

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Abstract: Algae are eukaryotic, photosynthetic lifeforms, they are chlorophyll-containing autotrophic thalloid plants. Algae are divided into two major categories (A) Microalgae: microalgae also known as blue-green algae or cyanobacteria are prokaryotic, microscopic unicellular algae having a diameter of 1-50. Cyanophyta (Blue-Green Algae), Pyrophyta (Dinoflagellates) Chrysophyta (Diatoms and golden-brown algae), and Chlorophyta (Green algae) are included in the micro-Algal group. Microalgae contain phosphorous (P), calcium (Ca), iron (Fe), vitamins- A, B, C, E, folic acid, biotin, beta-carotene, pantothenic acid and vitamin B12. (B) Macroalgae: macroalgae are eukaryotic, macroscopic multicellular algae, also known as seaweeds. The habitat of macroalgal species is marine water with the optimal availability of light. Macroalgal species have a simple structure consisting of thallus, lamina, kelp, holdfast and frond sorus, thus morphologically differentiating them from the typical terrestrial plant, consisting of complex tissue and organ organization. Macroalgae can be divided into three major groups based on their pigmentation Chlorophyceae, Phaeophyceae and Rhodophyceae.
Algal species can survive in extreme environmental conditions of pH, temperature, osmotic pressure, salinity, and exposure to Ultraviolet rays, and can defend themselves by the production of primary and secondary metabolites. In the field of Cosmeceuticals by using the products extracted from its biomass in cosmetic industries. Many algal species are now used widely for the treatment of various skin-related problems by acting as a moisturizer or texture enhancing, sunscreens, anti-wrinkling, etc. Algal extracts contain biologically active compounds that are used in the cosmetic industry. These compounds are often employed in the cosmetic industry as antioxidants, thickeners, water binders, etc. These extracts are found in skin and face care products such as anti-ageing creams, masks, lotions, etc., Ultraviolet (UV) protectants creams such as sunscreens, and hair care products. This topic will evaluate the properties and applications of bioactive compounds from algae for Human welfare in Cosmetic Industry.

Index Terms-Algae, cosmetics, UV protectants, bioactive compounds

I.INTRODUCTION

Algae produce primary metabolites such as oleic acids, vitamin E, vitamin B12, lutein, etc to defend its cellular components. Secondary metabolites are also generated under harsh conditions. These metabolites possess antibiotic and antimicrobial effects against pathogens and are known for their skin benefits, which include protection from UV radiations and prevention of rough texture, wrinkles, and skin flaccidity. It also avoids skin ageing due to the presence of antioxidant compounds. A variety of cosmetics are obtained using bio compounds.
In recent times, there is a lot of demand for cosmetics and requirements for natural raw ingredients which are safe and efficient in combating skin complications. Algae, both macroalgae and microalgae are valuable because they have beneficial bioactive compounds. Several beneficial metabolites can be obtained from algae, such as antioxidants, carotenoids, mycosporine-like amino acids (MAA), pigments, polysaccharides, and scytonemin. Nowadays, various algal strains are widely used in skincare products for various purposes, such as moisturizers, anti-wrinkle agents, texture-enhancing agents, and sunscreen.

II. MACROALGAE IN COSMETIC

Macroalgae are ecologically and economically the most important living forms. They have huge potential as a natural source of important nutrients, namely Fiber, Protein, Essential amino acids, Minerals, and Trace Elements. They also provide long-chain polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA) and liposoluble vitamins (e.g., β-carotene, vitamin E). This is of great interest to the cosmetic industry. These ingredients are used in cosmetic formulations either active substances, excipients, or additives.
Red algae produce a photosynthetic red pigment, phycoerythrin and phycocyanin along with chlorophyll. Some species of red algae used in cosmetics are *Irish moss*, *Gracillaria species*, *Porphyra species* etc.
Green algal photosynthetic pigment chlorophyll can trap light energy. It provides oxygen to the exposed surface of the algal species and prevents it from drying by moisturizing it. It also possesses an anti-inflammatory effect Some species of green algae used in cosmetics are *Chlorella vulgaris*, *Ulva lactuca* etc. β-carotene obtained from *Dunaliella salina* is used as colourants and food supplements as nutraceuticals as it is a precursor of vitamin

Brown algal Fucoxanthin pigment has tyrosinase inhibitory effects which help to reduce or control skin pigmentation, possesses an anti-inflammatory effect and also, improves collagen production. This pigment moisturizes the skin and keeps the cells become nourished. Some species of brown algae used in cosmetics are *Isochrysis, Laminaria digilata* etc.
Algal biomolecules and pigments are extracted and incorporated into cosmetic products with a wide range of functions. The metabolites of Algae, serve as agents for the treatment of skin, like anti-wrinkle or moisturizing agents. Polysaccharides such as alginates, carrageenan, and agar derived from Phaeophyceae and Rhodophyceae act as gelling agents in various shampoos, lotions, etc. Apart from this, the ingredients of macroalgae possess stabilizing, preserving properties.
Macroalgae are a natural resource that can be widely used in natural products. The marine environment is extremely demanding, competitive, and aggressive. marine organisms, including macroalgae, are forced to develop an efficient metabolic response or activity as a self-defence mechanism, by producing secondary metabolites that allow them to preserve their survival and protect themselves against external threats. Therefore, sea biodiversity presents the opportunity to explore these molecules and find novel and natural bioactive compounds. Some species of macroalgae are used as a source of phycocolloids, namely, agar and carrageenan extracted from red algae such as *Gracilaria, Chondrus,* and *Gelidiella*, among others, and alginate from brown algae like *Ascophyllum, Laminaria*, and *Sargassum*. Agar and carrageenan form thermally reversible gels, while alginate gels do not melt on heating. These compounds are industrially extracted and used as ingredients or additives.

Table 1: Various compounds found in Algae-their functions and applications

Name of compounds	Function	Application
Carrageenan	Thickening, gelling agent, binder and sensory enhancer	Bath and Shower gels
Carrageenan	Thickening and suspending agent	Skin Care
Carrageenan	Stabilizer and sensory enhancer thickening and suspending agent	Sun care
Carrageenan	Thickening agent, fixative agent and sensory enhancer	Hair care
Carrageenan	Thickening and suspending agent stabilizer and binder	Oral care
Alginate	Thickening and gelling agent	Shampoo and lotions
Alginate	Emulsification and viscosity	Lipsticks

III. SOME OF THE BIOACTIVE COMPOUNDS USED IN COSMETICS

A. Polysaccharides: Several macroalgae-derived sulphated polysaccharides (SPs), the chemical structure of these macromolecules varies according to the species. It has been reported that red macroalgae SPs, namely, xylomannan, galactans, and carrageenans, exhibit antiviral activity, and different polysaccharides like carrageenans (lambda, kappa, and iota), fucoidans, and fucans. De Souza and colleagues [1] found that fucoidan and lambda carrageenan exhibited the highest antioxidant activity and free radical scavenging activity against superoxide anions and hydroxyl radicals. Ulvans, in turn, is designated a water-soluble group typically found in green macroalgae, which are mainly composed of glucuronic acid and iduronic acid units together with rhamnose and xylose sulphates [2]. It has been reported that these compounds present a high antioxidant capacity against some reactive oxygen species (ROS), namely, superoxide and hydroxyl radicals.

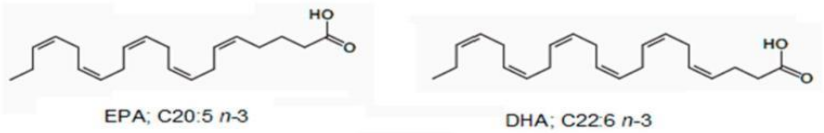
B. Proteins, Peptides, and Amino Acids: Protein content varies according to species, it is higher in Rhodophyceae, compared with Chlorophyceae and Phaeophyceae. Environmental conditions also affect their protein composition, because nitrogen availability may fluctuate due to water temperature, and salinity variations in light, affecting their nutrient supply. Peptides are made up of short chains of 2 to 20 amino acids. Their biofunctional properties depend on their amino acid composition and sequence. They can modify physiological functions, even in the skin, due to their ability to interact with target cells, binding to specific cell receptors or inhibiting enzymatic reactions. Macroalgae are an excellent source of amino acids and amino acids have which having almost all amino acids both essential and nonessential Amino acids constitute the natural moisturizing properties and promote collagen production in the skin. Some species of red macroalgae like *Palmaria* and *Porphyra* have high amounts of arginine in their composition widely used in cosmetic formulations.

Mycosporine-like amino acids are water-soluble metabolites with low molecular weight. They are characterized by a cyclohexenone or cycloheximide chromophore conjugated with a nitrogen residue of amino acid, amino alcohol, or amino group, with maximum absorption wavelengths ranging from 310 to 360 nm [3]. these amino acids protect macroalgae from UV radiation and have been described as important antioxidant compounds in red algae with reports that they are very

efficient photoprotector agents. Hence, they have great potential to be used as natural skin protection ingredients in photoprotective formulations.

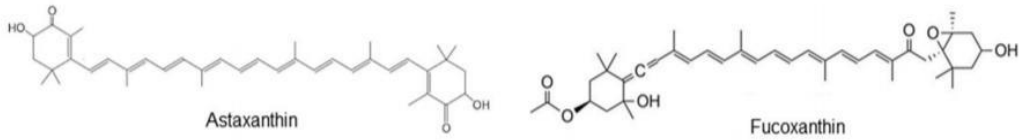
C.Lipids: Macroalgal lipids composition include essential Fatty Acids, triglycerides, phospholipids, glycolipids, sterols, liposoluble vitamins (A, D, E, and K), and carotenoids. Long-chain unsaturated PUFAs (LC-PUFAs) have C18, C20 or more carbons, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) are the most important, Alpha-linolenic acid (ALA) and docosapentaenoic acid are beneficial compounds used in cosmetic Industry.

D. Pigments and Phenolic Compounds: Macroalgae contain a wide variety of pigments that absorb light for photosynthesis. Three major photosynthetic pigments found in algae are chlorophylls, carotenoids (carotenes and xanthophylls), and phycobiliproteins. These compounds are responsible for macroalgae colour variations during their growth and reproduction



EPA; C20:5 *n*-3 DHA; C22:6 *n*-3

cycles. Chlorophylls and carotenoids are liposoluble molecules. Chlorophylls are the greenish pigments, the most abundant photosynthetic pigment, while others are known as accessory pigments. Within the carotenes group, β-carotene is the most important. Xanthophylls have also excellent antioxidant properties.



Astaxanthin Fucoxanthin

IV. MICROALGAE IN COSMETIC

Microalgae are a large and diverse group of unicellular, prokaryotic and eukaryotic microorganisms. They can grow in freshwater or seawater and play a key role in aquatic ecosystems as the primary producers responsible for around a half of photosynthesis on Earth. Unicellular microalgal species like *Spirulina*, *Chlorella*, and others find an active role in the cosmetic industry. The amino acids and proteins of algae possess a natural moisturizing ability for skin hydration and prevent drying of the skin cells. Other algal metabolites such as lipids (carotenoids, sterols), phycobiliproteins (phycocyanin) and pigments, contain anti-inflammatory and anti-oxidant activities. Microalgae synthesize a broad spectrum of compounds that have antioxidant and UV-absorbing properties, they exhibit photoprotective, antiaging and sunscreen activities. Therefore, these algal metabolites were recognized as promising ingredients for cosmetics and cosmeceutical formulations.

Biologically active compounds from microalgae have antiviral, antifungal, or antibiotic effects. Some of the interesting molecules or compounds, such as pigments, vitamins, fatty acids, and proteins, are primary, while others are secondary metabolites. Most commercially promising active microalgae substances are secondary metabolites that accumulate in cells under unfavourable environmental conditions for growth. The high potential of microalgae as raw materials for the cosmetic industries. It can be economically efficient since microalgae can grow autotrophically so the cultivation in bioreactors makes it possible to obtain more standardized raw biomass whose quality is less dependent on seasonal factors. Many substances of microalgal origin found extensive use in the cosmetic industry.

V. SOME OF THE BIOACTIVE COMPOUNDS USED IN COSMETICS

A. Inorganic substances: Mineral substances are accumulated by cells of microalgae and in the extracellular matrices in the form of ions, insoluble salts and compounds. 70 to 85 % of the mineral substances are water-soluble salts and 15 to 25% are insoluble Inorganic substances primarily iodine and zinc, are the constituents of enzymes, vitamins, pigments, and regulatory molecules, some trace elements in algae are iodine, zinc, chromium, nickel, aluminium, boron, potassium, sodium is also found and use in the manufacturing of cosmetic products.

B. Structural and reserve polysaccharides: Structural polysaccharide, cellulose is a major component of the cell wall of many algal species. It is a linear homopolymer of 300-10000 β-glucose molecules linked by β-1-4 glucoside bonds. The cellulose filaments are held together by hydrogen bonds, which gives the cellulose greater mechanical strength and elasticity. It does not break down when heated to 200° C and it is insoluble in water and weak acids. Polysaccharides of microalgae are divided into two groups according to the type of sugar bonds in their polymer chains. These are α-1,4-glucans and β-1,3-glucans. In cosmetics, mostly α-1,4- and α-1,6-glucan are used [7].

C. Microalgal lipids: Long-chain polyunsaturated fatty acids, biologically active long-chain polyunsaturated fatty acids (PUFA) such as γ-linolenic (GLA), eicosapentaenoic (EPA), docosahexaenoic acid (DHA) have great demand in cosmetics. The genus Schizochytrium is a rich source of DHA, tested for safety [8]. In the cosmetic industry, the "algae oil," a concentrate of the essential Omega-3 and Omega-6, PUFA is becoming more widespread. "Algal oil" from *Schizochytrium* species. (branded "DHA Gold"), which is approved for skin care products, in cosmetics, the product is an important ingredient for restoring the water-lipid mantle of the skin [9].

D.Pigments: i. *Chlorophylls*: Chlorophylls are pigments that absorb light in the blue and red regions of the visible spectrum. They are central to the photochemical conversion of light energy in photosynthesis. With the antimicrobial, anti-inflammatory effect of chlorophyll-based drugs, and their ability to stimulate not only hematopoiesis, but also the healing of wounds and ulcers as an antiseptic additive, chlorophyll is popular in cosmetics for oily skin, skin with acne, and care products for oily scalp. In cosmetics skin care, chlorophyll is also used as a pigment.

ii. Carotenoids: Carotenoids are divided into carotenes, the hydrocarbons devoid of oxygen, and xanthophylls, which contain oxygen. Carotenoids are biologically active compounds whose main functions in photosynthetic organisms are light-harvesting for photosynthesis and photoprotection. In addition, they have antioxidant, antibacterial, antiviral, antifungal, anti-inflammatory, and antitumor properties. Carotenoids are also used in the food, medicines, and cosmetics industry due to their beneficial effects on human health. The antioxidant activity of carotenoids determines their application as cosmetics ingredients and safe colourants. The main carotenoids that are currently commercially used are β-carotene, astaxanthin, lutein, canthaxanthin, zeaxanthin, and fucoxanthin [10]. In addition, lycopene and canthaxanthin. β-Carotene is a yellow-orange pigment. It is synthesized by photosynthetic organisms and participates in the photoprotection of chlorophyll. Microalgae normally accumulate the carotenoids as photosynthetic pigment while secondary carotenoids including β-carotene are the most common source of vitamin A and a powerful antioxidant.

E. MAA like Amino Acids: Mycosporin-like amino acids (MAA) are secondary metabolites found in marine organisms of any climate zone including microalgae, especially affected by high fluxes of solar radiation or hypersaline conditions [11]. In the course of evolution, cyanobacteria acquired UV-protective mechanisms, one of which is based on blocking by MAA. Prolonged exposure to ultraviolet (UV) radiation causes photo-ageing of the skin and several other disorders, including sunburn, and fine and coarse wrinkles, and increases the risk of skin cancer. Sunscreens are commonly applied to reduce the harmful effects of UV on the skin. Recently, there has been a growing demand for replacing chemical sunscreens with natural UV-absorbing compounds. MAA are promising alternative UV-absorbing compounds of natural origin which are highly soluble in water and do not generate ROS upon absorption of UV radiation. MAA protect against skin ageing and can exert antioxidant, and anti-inflammatory activity can also inhibit protein glycation and collagenase activity. They are considered to be anti-ageing components. Its high antioxidant efficiency is probably associated with a lower reduction potential and a greater ability to release electrons to stabilize and inactivate free radicals.

MAA used as sunscreens: Exposure to sunlight might be harmful depending on the amount of absorbed radiation and the depth of its penetration to the skin, reaching the dermis layer, which leads to diverse skin damages like sunburn, edema, blisters, phototoxic reactions, photoallergy, photo-sensitivity. A promising alternative to existing chemical and physical sunscreen filters is the use of multifunctional MAA, which is also suitable for cosmetics formulations. The application of MAA prevents UV-induced damage and can protect the skin from photoaging and inflammation.

VI. IMPORTANCE OF ALGAE IN COSMETICS

i. **Skin Benefits**: Many external factors, including UV radiation, climate conditions, and air/environmental pollutants (e.g., tobacco smoke) can affect the skin and promote premature ageing, continuous exposure leads to oxidative stress caused by the imbalance between oxidants and antioxidants, which affects skin health. Skin ageing produces several changes: it becomes thinner, more fragile, and progressively loses its natural elasticity and ability to maintain hydration. In the cosmetic field, the primary functions of natural ingredients may be antioxidant, collagen boosting, and anti-inflammatory. Bioactive compounds used in antiaging care include protection against free radicals, prevention of skin flaccidity and wrinkles, anti-photoaging, photoprotection against UV radiation, moisturizing, and skin whitening.

ii**. Antiaging and Antioxidant Effects**: In biological systems, ROS and reactive nitrogen species (nitric oxide) are products of normal cellular metabolism. they can play a dual role, as they can act as both damaging and beneficial species. Oxidative stress, caused by an overproduction of ROS, can induce serious damage in several cell structures (lipids and membranes, proteins, and DNA). At the same time, ROS and RNS also participate in several redox regulatory mechanisms of cells to protect them against oxidative stress and maintain their "redox homeostasis". Bioactive compounds, namely vitamin E, vitamin C, superoxide dismutase, coenzyme Q10, zinc sulphate, polyphenols, and carotenoids have been used in cosmetic products as free-radical-scavenging molecules.

iii. **Moisturizing/Hydration Action**: Moisturizing and hydration are very important for skin and are essential to maintaining its healthy texture and elasticity. Polysaccharides play a very important role in cosmetics as moisturizers. These macromolecules have a high capacity for water storage and can be linked to keratin through hydrogen bonds thus improving skin moisturization. According to Wang and colleagues [4] Polysaccharides extracted from *Saccharina japonica* revealed better moisturizing properties than hyaluronic acid, suggesting that these polysaccharides could be an interesting ingredient for cosmetics. The authors also found that the sulphated group was a main active site for moisture absorption and moisture retention ability and that the lower-molecular-weight polysaccharides presented the highest moisture absorption and moisture retention abilities. Phycocolloids, like alginate and protein, attach to skin proteins to form a protective barrier for moisture loss regulation.

iv. **Photo-Protective Action**: UV radiation is very harmful to the skin and causes skin cancer. The use of photoprotective products with UV filters to prevent and protect the skin from several types of damage, like sunburn, photo-ageing, or even skin cancer. Bioactive compounds able to absorb UV radiation can protect human cells from UV-induced cell death and suppress UV-induced ageing in human skin. Macroalgae have developed mechanisms to prevent damage from UVB and UVA radiations, either by producing screen pigments, like carotenoids or by phenolics.

v**. Whitening/Melanin-Inhibiting Effects**: Melanin is, a factor for skin colour, absorbs UV radiation and prevents free radical generation, protecting skin from sun damage and ageing. The abnormal production of melanin can be a dermatological condition and a serious problem. Tyrosinase catalyzes melanin synthesis, it is possible to regulate melanin

biosynthesis, by protecting skin and avoiding UV exposure, or by inhibiting tyrosinase action or melanocyte metabolism and proliferation.

vi. **Anti-Inflammatory Effects**: An inflammatory process causes oxidative stress and reduces cellular antioxidant capacity. A large amount of produced free radicals react with fatty acids and proteins of cell membranes, permanently damaging their normal functions [5]. Senevirathne and colleagues [6] evaluated the antioxidant and anticholinesterase activities, as well as the protective effects of enzymatic extracts from *Porphyra tenera* against lipopolysaccharides (LPS) authors, concluded that *Porphyra tenera* could be a valuable source of natural antioxidants and anti-inflammatory ingredients for cosmetic purposes. Antiviral and Antibacterial Effects: Algae have a higher antioxidant capacity and stronger antibacterial effects against *Escherichia coli* and *Staphylococcus aureus*. This could be of particular interest for the development of natural preservatives to be used in cosmetic formulations.

Table 2: ALGAL BIOACTIVE COMPOUNDS AND THEIR USES IN COSMETICS

Bioactive compounds	**Algae**	**Uses in cosmetics**
Beta Carotene	*Dunaliella salina*	Antioxydant and Anti inflammatory
Chlorophyll	*Chlorella*	The pigment used in deodorants
Canthaxanthin	*Nannochloropsis salina*	Tanning products
Phycocyanin	*Spirulina plantensis* and *Porphyridium*	Eye shadows
Lycopene	*Anabaena species*	Antioxidant, Antiaging and used in sunscreen
Scytonemin	*Scytonema*	Sunscreens
Vitamin E (Alpha-Tocopherol)	*Dunaliella salina*	Antioxidant
Polysaccharides	*Chlorella & Macroalgae*	Moisturising and thickening agents
Sulphated polysaccharides	*Porphyridium & Rhodella reticulata*	Antioxidant
Astaxanthin	*Haematococcus pluvialis*	Antioxidant properties
Phycocyanin	*Spirulina*	Antioxidant properties
Phycoerythrin	*Porphyridium*	Pigment for eyeliner and lipstick

Table 3: SOME ALGAL BRANDS & PRODUCTS

Company name	**Product**	**Algae used**
Nykaa	Iraya algae body serum	Green algae & *Spirulina*
L'Oreal	Pure face mask	Red algae
Dove	Dove regenerating repair shampoo	Red algae
Osea	O***sea's*** eyes & lips	Red algae (*Chondrus crispus)*
Algenist	REVEAL colour-correcting eye serum brightener	Green algae (*Dunaliella salina), Haematococcus pluvialis*

VII. CONCLUSIONS

Due to awareness about skin, hair, lips, photoaging and several diseases due to sun exposure, an increase in consumption of various natural cosmetic products in which algae extracts are also used widely and commonly. Algae are a source of added-value compounds, with scientific evidence showing their benefits for human health and wellbeing, antiaging, antioxidant, moisturizing, collagen-boosting, photo-protective, whitening and melanin-inhibiting, anti-inflammatory, and antiviral and antibacterial activities of algal compounds are widely used in the cosmetic industry.

Algae are a rich source of substances or compounds with a great potential to resist the negative effects of stresses acting on human skin cells. In many cases, these compounds appear to be less toxic, less allergenic and, in general, more "biocompatible". Microalgae are loaded with natural and safe compounds which are widely used in cosmetics.

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