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A Brief Review Using of Algae in Cosmetics

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Abstract - Macro and microalgae found in lakes, rivers, and oceans have shown to be very important as a source of bioactive compounds for cosmetics in our daily lives. Algal bioactives are being studied more because they contain vitamins, antioxidants, essential fatty acids, polysaccharides, and pigments. The world needs more natural and long-lasting cosmetic ingredients. These things keep skin moist, protect it from UV rays, and fight free radicals, which makes it look and feel better. Even after using them for a long time, algae-based cosmeceuticals have been shown to work as well as other products.This is a rapidly growing and economically promising area of the biological technology industry. It promotes the use of renewable resources in the cosmetics industry and the health of the skin. The use of natural substances has increased significantly, particularly in cosmetics.The review aims to look into the ecological importance, characteristics, and usefulness of algae in cosmetics. It will focus on how rich algae are in vitamins, antioxidants, and essential fatty acids, and how they can be a safe, healthier, and cheaper alternative to synthetic products. Biotechnology has come a long way in the last few years, making it easier to get bioactive compounds from algae and clean them upThis has led to new ways to make things that work better and last longer. Using green chemistry and nanotechnology in cosmetics that contain algae extracts has led to new ways to make the natural ingredients more stable, effective, and able to penetrate the skin. As more people learn about products that are good for the environment and don't hurt animals, algae-based cosmetics, which combine scientific progress with care for the environment, are likely to have a big impact on the future of the beauty industry.

مراجعة قصيرة لاستخدام الطحالب في مستحضرات التجميل

ابتهال موسى جعفر و ميثم عبدالله الشاهين
قسم علوم البيئة ، كلية العلوم ، جامعة البصرة ، البصرة – العراق

المستخلص - تظهر الطحالب المجهرية والكبيرة التي تنمو في البحيرات والأنهار والمحيطات قدرة متميزة كمصادر للمركبات الحيوية النشطة المستخدمة في مستحضرات التجميل. ونظرًا لغناها بالفيتامينات ومضادات الأكسدة والأحماض الدهنية الأساسية والسكريات المتعددة والأصباغ، فقد حظيت الطحالب باهتمام متزايد بوصفها بدائل طبيعية ومستدامة للمكوّنات التجميلية الصناعية. تدعم هذه المركّبات صحة البشرة ومظهرها من خلال خصائصها المرطّبة والمضادّة للشيخوخة والمضادّة للأكسدة والواقية من الأشعة الضوئية. وقد أثبتت المنتجات التجميلية القائمة على الطحالب فعاليتها كبدائل آمنة، إذ تُظهر نتائج إيجابية حتى بعد الاستخدام طويل الأمد. ويُعد هذا المجال من أسرع القطاعات نموًّا وأكثرها وعدًا من الناحية الاقتصادية في الصناعات الحيوية، حيث يُعزّز استخدام الموارد المتجدّدة في قطاع مستحضرات التجميل ويُسهم في تحسين صحة البشرة. يهدف هذا البحث إلى استكشاف الأهمية البيئية والخصائص الكيميائية الحيوية والإمكانات التجميلية للطحالب، مع التركيز على دورها كبديل طبيعي آمن وصحي واقتصادي للمنتجات الاصطناعية. بالإضافة إلى ذلك، فقد حسنت التطورات الحديثة في مجال التكنولوجيا البيولوجية الإجراءات الخاصة باستخراج وتنقية المواد الكيميائية النشطة من الطحالب، مما يفتح إمكانيات جديدة لتقنيات إنتاج أكثر فعالية وصديقة للبيئة. إن دمج الكيمياء الخضراء وتقنية النانو في تركيبات مستحضرات التجميل التي تستخدم مستخلصات الطحالب قد خلق فرصًا جديدة لتعزيز استقرار المكونات الطبيعية وفعاليتها وقدرتها على الاختراق الجلدي.

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من المتوقع أن تلعب مستحضرات التجميل القائمة على الطحالب، والتي تجمع بين الابتكار العلمي والمسؤولية البيئية، دورًا مهمًا في تحديد مستقبل صناعة الجمال مع تحول وعي المستهلك نحو المنتجات الخالية من القسوة والصديقة للبيئة.

الكلمات المفتاحية: الطحالب؛ المركبات الحيوية؛ مستحضرات التجميل.

Introduction

The field of cosmetic chemistry has developed quickly in recent years. This trend is associated with growing public awareness of the importance of maintaining one's looks and health. In order to maintain a youthful appearance and healthy skin for as long as possible, cosmetic substances and products are being sought after. In modern cosmetology, bioactive compounds with natural origins have grown in popularity. Substances that specifically affect an organism's physiological and metabolic processes are known as biologically active substances (Imhoff *et al*.,2011; Barbosa-Pereira *et al*.,2013; Hardouin *et al*.,2014).

Many types of biological action have been identified, for example, antioxidative, anti-inflammatory, immunostimulating, and many others.

Among eukaryotes and prokaryote, algae are incredibly diverse, and throughout their evolutionary histories, they have interacted with one another in several intricate ways. Algae are found in three of the four major groupings of eukaryotes that are capable of producing energy through photosynthesis. In other words, a large number of algae are primarily photosynthetic and share biological and ecological roles with plants (Stengel *etal*.,2011). The characteristics of Algae, like rising biomass production and environmental status adaptation, are giving considerable interest in producing a variety of products (Kumar *etal*.,2020; Nowruzi *etal*.,2020).

The study of micro and macro algae has clarified the biodiversity of molecularly importance for curative proteins, cosmetic applications, and food (Skjanes *etal*.,2013).

Because microalgae contain fatty acids, tocopherols, sterols, proteins, carbohydrates, vitamins, minerals, antioxidants, and colors (such as carotenoids and chlorophyll), they are also important food producers, mostly for animal feed (Borowitzka. 2013).

Macroalgae are ecologically and economically important. As a natural supply of vital nutrients such as protein, essential amino acids, fiber, minerals, and trace elements, they also supply liposoluble vitamins (including vitamin E and β-carotene) and long-chain polyunsaturated fatty acids (PUFAs) like eicosapentaenoic acid (EPA). The cosmetics business is quite interested in this. These components are employed as additives, excipients, or active compounds in cosmetic compositions. Red algae produce photosynthetic red pigment, phycoerythrin. In addition to chlorophyll a, *Porphyra*, *Chondrus crispus*, *Gracillaria*, and other red algae species are utilized in cosmetics (Singh and Purwar 2022).

There are many studies about macroalgae (Vaibhav and Sahasrabuddhe, 2018) suggested cosmetics such as in the treating of tanning, skin aging, skin wrinkles, protection of roughness, antibrowning reaction, , and whitening. kim *et al*. (2011) explain the importance of polysaccharide in decreasing the hazard of photoprotection by attaching with Fibroblast growth factors and save them from proteolysis. Studied Makhubalo *etal.* (2024) the methanol extracted from *Macrocystis pyrifera* raises the structure of syndecan-4, a protein used in anti-aging compounds, and contains hyaluronic acid. Kamei *etal*. (2009) proposed this Sargafuran extract from *Sargassum macrocarpum* that demonstrates antibacterial efficacy against the species *Propionibacterium acnes*, which is useful for developing prodcuts skincare to stop acne.

Algal phytoplankton is often regarded as an essential component of the global ecology. Solar energy is transformed into sustainable biomass by the intricate biochemistry of unicellular and multicellular aquatic algae. Through a mild chemical reaction, algae synthesize a wide range of

bioactive compounds, including vitamins, lipids, polysaccharides, polyunsaturated fatty acids, carotenoid colors, and antioxidants (polyphenol and tocopherol). These expensive biomolecules are used in a variety of industries, contain fish and animal feed, green biomethane, pharmaceutical supplements, food additives, and cosmetics (Diaconu, 2020; Han *etal*.,2019). Phytoplankton can survive in many different places, from coastal waters with lots of nutrients to the wide open ocean. Because they can adapt, you can grow phytoplankton in controlled environments. This means that they can be used for cosmetics in a way that is both renewable and sustainable (Figure 1). Also, they can make a lot of biomass because they grow so quickly, and this biomass can be collected and used to make different beauty products (Hochfeld and Hinners 2024).

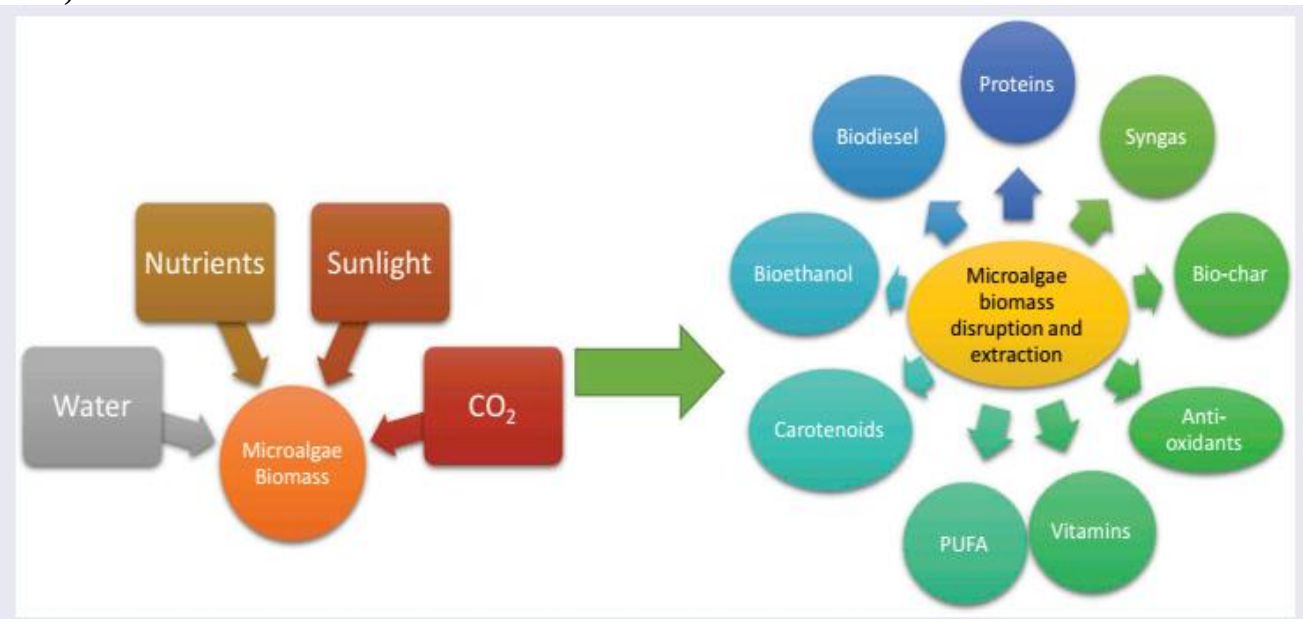

Figure 1. Important microalgae in environment and pharmaceutical supplements, food additives, and cosmetics (Koyande *et al.*,2019)

The Ecological Importance of micro algae (Phytoplankton) in cosmetics and they are essential source of food for aquatic organism .They serve as the base of the marine food web as primary producers, sustaining a wide range of organisms, from larger fish and marine mammals to zooplankton . Figure 1. Important microalgae in environment and pharmaceutical supplements, food additives, and cosmetics (Koyande *etal*.,2019).

Phytoplankton are vital to the survival of life on Earth since they are thought to be responsible for around half of the oxygen produced on the planet. Additionally, as they die and descend to the ocean floor, they contribute to the sequestration of carbon in ocean sediments, which is crucial in the fight against global warming (Naselli-Flores and Padisák 2023), also using algae to remove heavy metals from wastewater system(Ibrahim,2021; Al-Atbee *etal*., 2025).

Historical Context of Algae in Cosmetics:

Applications of Algae in Cosmetics as people's knowledge of the natural advantages and sustainable practices related to marine resources has grown, so has the use of algae in cosmetic formulations. This section explores the types of algae utilized, their historical context, the numerous skincare benefits they provide, and the advancements influencing its use in cosmetics (Ding *etal*.,2022).

Types of Algae Used in Cosmetic Products:

The cosmetics company utilizes a variety of algae species from freshwater and marine environments, including macro- and microalgae. The many characteristics of the algae employed indicate their diversity. The following are the species that are most frequently utilized in the cosmetics industry:

Brown algae (Ochrophyta),green algae (Chlorophyta), and red algae (Rhodophyta), are examples of macroalgae, (Lee *etal*.,2020).According to (Chia, *etal*.,2018) macroalgae are mostly prevalent in marine environments. They can be grown on vast stretches of the seashore or found naturally. Algae grow by using the sea's natural nutrients (Sudhakar *etal*.,2018).

Photosynthetic pigment (Chlorophyll a) found in Chlorophyta and has the ability to capture light energy. *Ulva lactuca*, *Chlorella vulgaris*, and other green algae species are utilized in cosmetics. Because it is a precursor of vitamin, β-carotene, which is extracted from *Dunaliella salina*, is utilized as a colorant and in dietary supplements as nutraceuticals. Brown algae contain the pigment fucoxanthin that use as anti-inflammatory properties, augmentation of collagen, and inhibits tyrosinase, that helps to diminish or regulate pigmentation of skin. Importance of the pigment to keep the skin hydrated and nourish the cells. *Laminaria digilata* and *Isochrysis* are the brown algae species used in cosmetic applications(Singh and Purwar 2022).

These many kinds of algae are highly prized in the creation of skincare, haircare, and body care products since they not only improve the effectiveness of cosmetics but also add to their sensory qualities.

Bioactive ingredients derived from algae used in cosmetics:

Natural bioactive substances containing astaxanthin, lutein,β-carotene, and fatty acids, which are all in high demand right now, can be found in large quantities in microalgae (Molino *etal*.,2020).As shown in Figure 2, macroalgae are a new source of biologically active substances including proteins-peptides, carotenoids,lipids, polyphenols, and polysaccharides. These compounds hold great potential for the manufacturing in cosmetics and food (Li *etal*.,2018;Pimentel *etal*.,2018; Gomez *etal*.,2020).

We must create sustainable, effective, and ecologically friendly extraction techniques if these valuable chemicals are to be used industrially as substitutes for conventional components (Gomez *etal*.,2020). Microalgae and macroalgae are renewable sources of bioactive compounds that can be used in an industrial application. Bioactive substances extend the body with important nutrients and also have important medicinal and cosmetic effects, such as being antibacterial, antioxidant, anti-inflammatory, and photoprotective (Gupta *et al*., 2021). Algae are used to conserve the skin from oxidative effect and early aging because they have a lot of carotenoids and phenolic compounds that can neutralize reactive oxygen species (ROS) (Zouari *et al*., 2022). Polysaccharides like alginate, fucoidan, and carrageenan come from algae and are commonly used in cosmetics because they can form a film and keep the skin moist. Pimentel *et al*. (2018) show that these biopolymers keep skin hydrated by forming structures that act like barriers to keep water in and keep skin soft. Polyunsaturated fatty acids (PUFAs) are important for keeping the epidermal barrier strong and helping the body fight inflammation (Li *et al*., 2018).

Enzymatic hydrolysis, ultrasonic-assisted extraction, and supercritical CO_2 extraction are regarded eco-friendly ways to get chemicals substance of algae. These methods are becoming very important because they keep the chemicals active and boost production (Gomez *et al*., 2020). Making things on a large scale is cheaper and safer for the environment when you use green extraction methods.

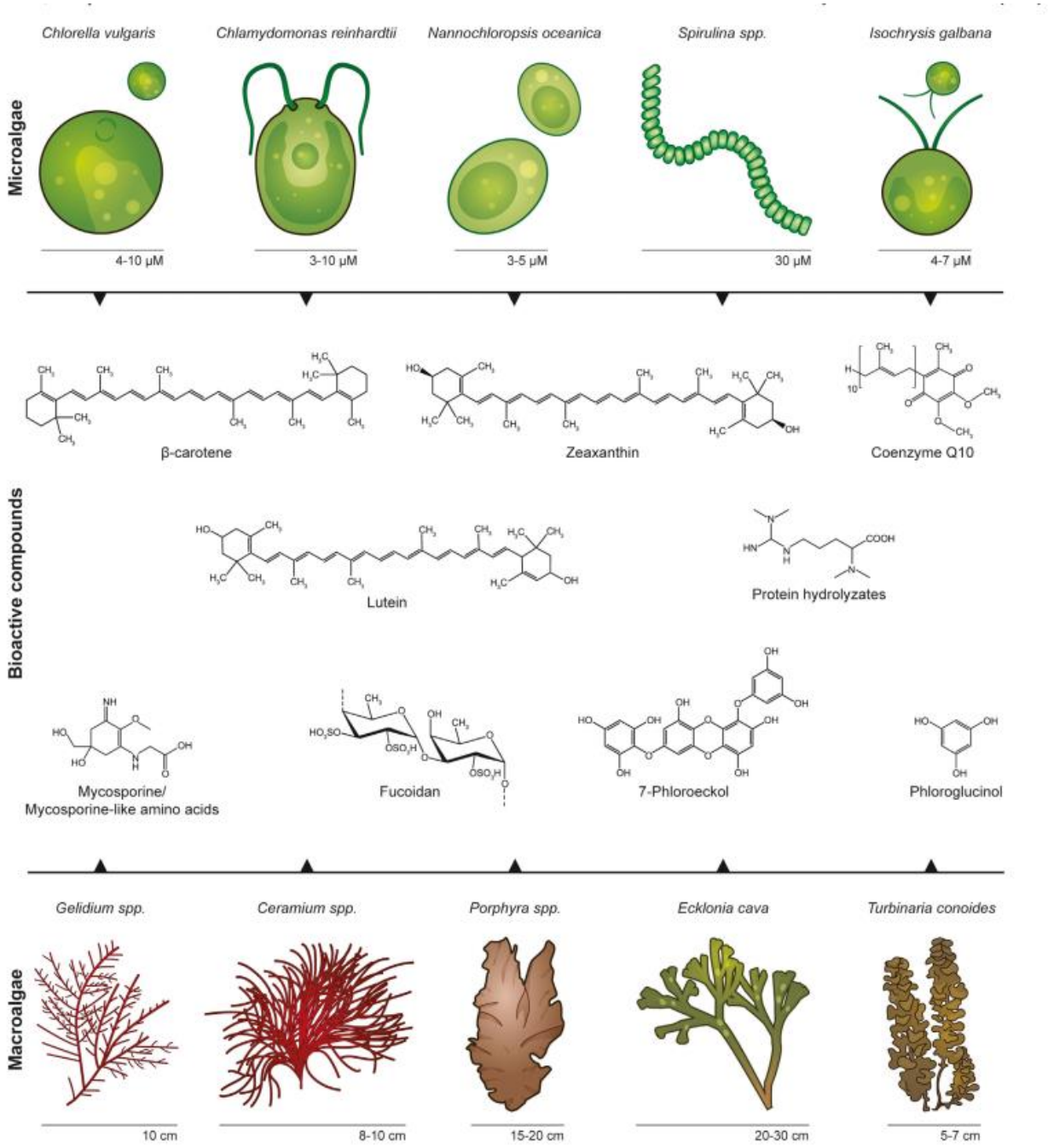

Figure 2. Bioactive ingredients in microalgae and macroalgae (Aslam *etal*.,2021)

Benefits of Algae in Skincare

Because marine algae products contain, thickening agents, sunscreensskin sensitizers, antioxidants, and moisturizing agents that increase skin's aptitude to withstand tanning,abrasions, and other conditions, they can be used as a substitute for cosmetics (Chauhan *etal*.,2022).Table 1. Marine algae are broadly classified into three groups: green algae (Chlorophyta), brown algae (Ochrophyta, class Phaeophyceae), and red algae (Rhodophyta, class Rhodophyceae), The

following are some of the many qualities that these marine algae have that make them useful in cosmetic.

Table 1: Algae species and their skin benefits Ma= Macroalgae, Mi= Microalgae(Chauhan *etal*.,2022).

No.	Name of Algae	Types	Activity
1	*S. japonica*, *Chondrus crispus*, and *Codium tomentosum*	Ma	Moisturizing agent
2	*Chlorella vulgaris and Spirulina maxima*	Ma	antioxidants
3	Sea Palm (Postelsiapal maeformis)	-	Skinsoftening, anti-wrinkle, nourishing, moisturizing, antiinflammatory
4	*Chlorella vulgaris*	Mi	de-pigmentation, anti-aging, moisturizing and thickening agent
5	*T. decurrens*	Ma	antioxidant activity
6	*Chondria baileyana*	Mi	antioxidant activity
7	*Chaeloceros sp.*,*Monodus sp.*, *Thalassiosira sp.*, and *Chlorococcumsp.*	Mi	anti-aging
8	*Ulva lactuca*	Ma	Moisturizing andanti-inflammatory agent
9	*Hizikia Fusiforme*	Ma	Whitening agent
10	*Fucus vesiculosus*	Ma	Skin softness andelasticity
11	*Nostoc sphaericum*	Mi	Antioxidant: radical scavenging, UV protectiv
12	*Ecklonia kurome, Isenia bicyclis, Ecklonia stolonifera, Hizikia fusiformis* , and *Ecklonia cava*	Ma	Antioxidant
13	*Tetraselmiss uecica*	-	Protective activity
14	*Laminaria japonica*	Ma	Skin Moisturizing effect
15	*Ascophyllum nodusum*	Ma	Smoothing agent and Anti-ageing
16	*TetraselmissIsochyrsis*	Mi	Ant irritant and Anti-Oxidant
17	*Spirulina platensis*	Mi	Antioxidants Moisturizing agent
18	*Postelsiapal maeformis*	Mi	Anti-oxidant andAnti-inflammatory agents
19	*Mastocarpus stellatus*	Mi	Stabilizing agent
20	*Poryphyra tenera*	Ma	Photo Protectionactivity
21	*Cylindrotheca closterium*	Mi	Antioxidant
22	*Padina crassa*	Ma	Antioxidant
23	*Cystoseira nodicaulis*	Ma	Anti-melanogenic (whitening)

UV Rays on the Skin Effect:

The skin is a specialized organ that guards against environmental stressors and water loss. The epidermis, dermis, and hypodermis are its three layers. While the dermis concentrates on tissue stability and healing, the epidermis's keratinocyte and melanocyte cells fix damaged skin. Acne, eczema, dermatitis, hives, psoriasis, and pityriasis rosea are among the conditions that affect the skin (Tabassum and Hamdani 2014). Humans are typically exposed to UV radiation from excessive sun exposure, which can have a variety of negative cell effects, such as destruction of DNA and skin diseases (Tan *etal*.,2019). UVA radiation, which is found between 315 and 400 nm, UVB rays, which is found between 280 and 315 nm, and UVC rays radiation, which is found between 100 and 280 nm (D'Orazio *et al.*,2013*)* Skin wrinkles and aging are caused by UVA

rays that can penetrate the skin's dermis layer and indirectly cause DNA mutation. By shrinking the telomeres in the strands of DNA and decreasing its capacity to promote melanin synthesis, UVA can cause cancer and cause freckles, sun tanning, and redness. UVB rays have the ability to directly harm skin cell DNA and cause skin cancer by penetrating the outer layer of the skin. Although UVC is very bioactive, humans are not exposed to it since the ozone layer absorbs the majority of it. Furthermore, the oxidative damage brought on by UV light is a major contributor to melanogenesis, cancer, aging, and inflammation *;* (Amaro-Ortiz etal.,2014) Figure 3.

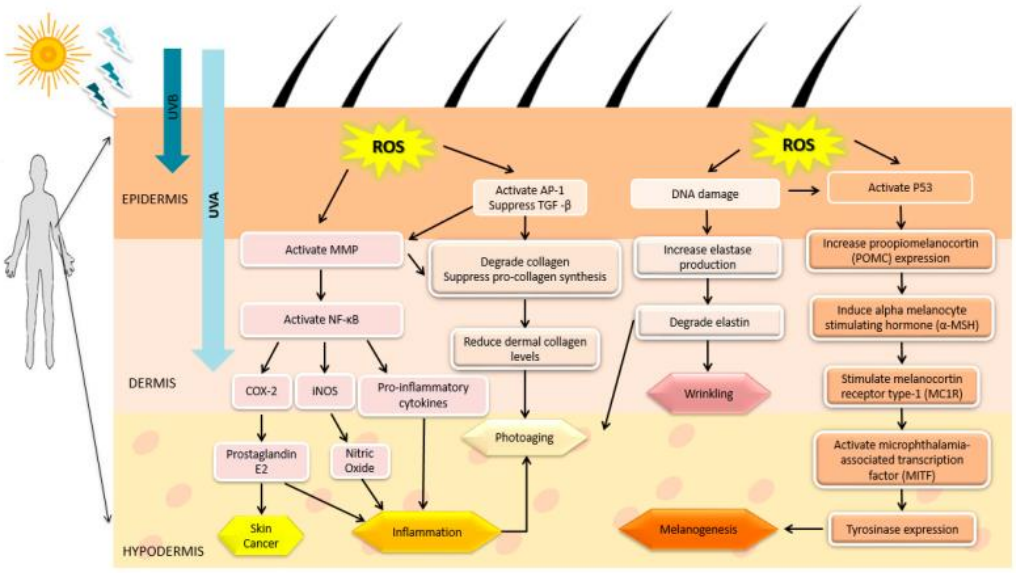

Figure 3. UV Rays and relationship with the Skin (Thiyagarasaiyar etal.,2020).

Compounds Derived from Algae use in Cosmeceutical Application

Phlorotannin bioactive compounds is produced from brown algae many cosmeceutical activities, such as anti-inflammation, anti-melanogenesis, anti-aging, and antioxidant (Shibata *etal.*,2002; ; Yoon *etal.*,2009 Thomas and Kim,,2013*)*. Also, fucoidan, an extract from brown algae, contributes to anti-melanogenic, anticancer, and anti-inflammatory (Anastyuk *etal.*,2012*;* Fernando *etal.*,2017*;* Wang *etal.*,2017*)*. Green and red seaweed and microalgae produce Mycosporine, such as amino acids, acts antioxidant, anti-aging, and anti-inflammation(Sakai *etal.*,2011*;* Suh *etal.*,2014*;* Hartmann *etal.*,2015*)*shown in Figure 4.

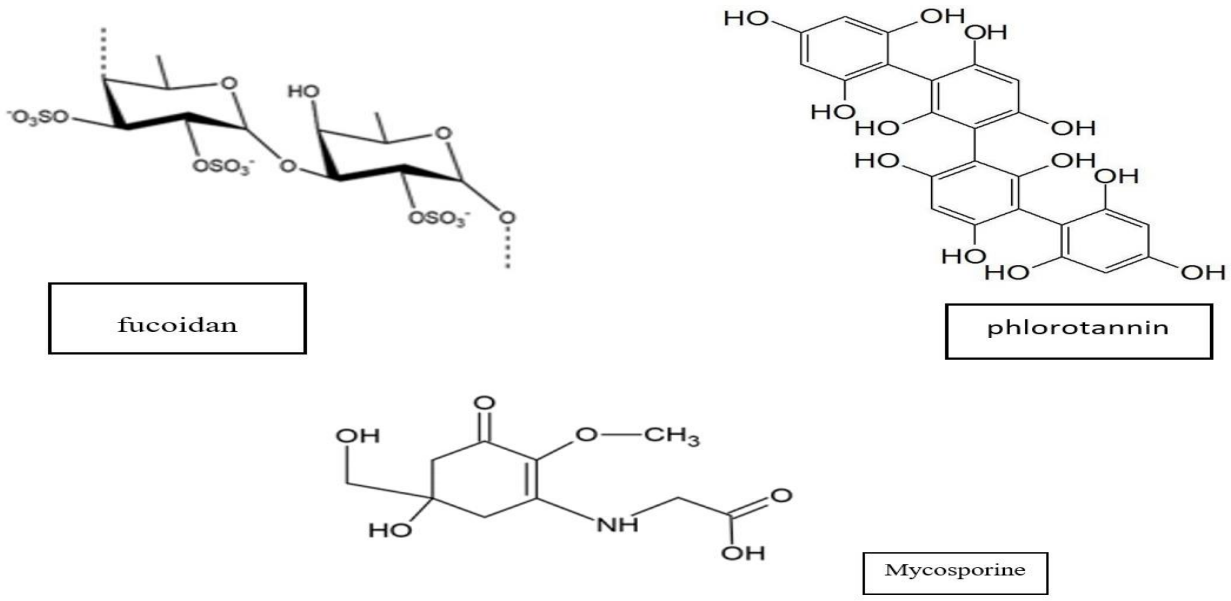

Figure 4. Chemical structure for bioactive compounds from algae.

Antioxidant Properties of Algae:

Benefits for the Skin: Numerous outside variables, such as UV rays, weather patterns, and air and environmental contaminants (like tobacco smoke), can harm the skin and accelerate the aging process. Prolonged exposure causes oxidative stress, which is brought on by an imbalance between oxidants and antioxidants and compromises the health of the skin. In addition to being thinner and more delicate, skin gradually loses its natural suppleness and capacity to retain moisture as it ages. Antioxidant, collagen-boosting, and anti-inflammatory properties may be the main uses of natural substances in cosmetics. Protecting against free radicals, preventing wrinkles and flaccidity, antiphotoaging, UV photoprotection, moisturizing, and skin whitening are all examples of bioactive substances utilized in antiaging care *(*Singh and Purwar 2022).Compounds that include antioxidants are beneficial for radiant skin. According to(Kohen and Nyska 2002).

Antioxidant compounds have significant commercial potential in the medical, food, and cosmetic industries because they protect against a number of diseases (such as chronic inflammation, atherosclerosis, cancer, and cardiovascular disorders) and aging processes.

Antioxidant substances also aid in the reduction of wrinkles, dark circles, and dark spots. *Spirulina maxima* and *Chlorella vulgaris* are two examples of algae species that are good suppliers of antioxidants *(*Barbosa-Pereira *etal*.,2013).

Nutritional Value of Algal Extracts:

Algal extracts are nutrient-dense, containing a variety of vitamins (such as A, C, E, and several B vitamins), minerals (including magnesium, calcium, and iron), and essential fatty acids. These parts are very important for keeping skin healthy. Vitamins A and C, for example, are known to help cells turn over and make collagen, which makes skin firmer and younger-looking.

Also, some algae have omega-3 and omega-6 fatty acids in them, which help the skin barrier work and keep it hydrated. This makes them especially good for people with dry or sensitive skin.

Algae can be found in many beauty products. They are used in skin creams for dry, damaged, and oily skin that is prone to acne because their active ingredients work in so many different ways. Algae extracts are used in a lot of different products, such as face masks, tonics, cosmetic balms, milks, skin-firming creams, sunscreens, soaps, shampoos, hair conditioners, peeling creams, shower gels, and color cosmetics (Molski 2010; Pielesz 2010; Martini 2014).

Conclusions:

Natural raw materials that are safe and work well are becoming more and more important. Algae-based cosmeceuticals stand out as promising alternatives, showing consistent positive effects even after long-term use. This industry not only makes a lot of money, but it is also one of the most exciting parts of biotechnology. Algae are good for your skin because they are full of nutrients that may help it. Their metabolites, which include proteins, polysaccharides, and mycosporine-like amino acids, can be used in many ways. Cosmetics made from algae are becoming more popular as natural ways to fix skin damage because they are antioxidants, anti-aging, anti-inflammatory, anti-wrinkle, and collagen-stimulating. However, more research is needed to fully understand how they affect human health over time.

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