REVIEW ARTICLE

An Insight Into Skincare and Antiaging Products Derived From Marine Origin

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Abstract

Marine resources are attracting significant attention from the cosmetics sector as a source of active ingredients. The oligo-elements like iron, copper and zinc, as well as proteins, amino acids, carbohydrates and vitamins A, B and C, are abundant in both micro- and macro-algae. These active components provide a range of benefits including hydration, firmness, shine, protection and slimming effects. Marine life is found in a variety of environments, each offering unique compounds with beneficial properties. Organisms living in places with high UV radiation levels, like tropical regions or shallow seas, can create compounds that provide photoprotection. Similarly, microbes that thrive in extreme conditions, such as hydrothermal vents, can produce substances with antioxidant properties. Polysaccharides from marine algae, such as alginate and carrageenan have been developed as cosmetics owing to their moisturising and skin-barrier enhancing properties. The scientific community believe that harnessing the potential of marine bioactive compounds is highly beneficial as medicinal products. By exploiting these resources, the skincare industry can develop innovative medicinal products that promote healthy, youthful skin while supporting environmental sustainability. In the present review, we have discussed the compounds derived from marine sources and their skin-nourishing properties marine-derived compounds, emphasising their role in developing novel skincare and antiaging products.

Key words: Marine biology; Bacteria; Moisturising effect; Algae; Anti-aging; Cosmetics; Ultraviolet rays; Photoprotection.

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Introduction

The contemporary way of life places a premium on personal care and appearance, drawing more and more consumers to products designed to enhance or change the appearance of skin, hair and nails.[1, 2] The human skin is the biggest organ and has a vital protective function. Human skin ages, losing its original elasticity and moisturising properties as well as becoming thinner. With age, the skin becomes more fragile, flabby, wrinkled and dry.[3, 4] The cosmetics industry is extremely dynamic, with new concepts being generated on a regular basis in addition to new goods being released at a rapid speed.[2, 5, 6] "Any mixture or substance intended to be contact with the teeth and the mucous membranes of the oral cavity, or with the external parts of the human body (external genital organs and epidermis, hair, nails, lips) with the principal or exclusive objective to clean, perfume, or protect them, or, change appearance or keeping them in good condition" is the definition of cosmetics as of July 2013, per European Commission (EC) regulation No 1223/2009.

According to galenic, cosmetics are composed of combination of raw materials that combined to create a formulation that is relatively stable, homogenous and complicated. Three major categories can be applied to these ingredients: additives, excipients and active principles.[1] The last several years have seen an increase in consumer desire for green and eco-friendly products. This trend is particularly noticeable in the cosmetics sector, which is a competitive and ever-evolving global market that requires natural, safe and effective ingredients to produce state-of-the-art skin care products.[1, 7, 8] This sector is constantly looking for fresh concepts, especially ones that incorporate active principles. In this regard, the marine world presents a plethora of opportunities. The cosmetics business already makes extensive use of macro-algae; the potential of marine bacteria and microalgae remains largely unharnessed. They do, however, differ greatly from one another. Although certain marine bacteria and algae are currently generated commercially, only a small percentage have been discovered and identified. They have a great deal of potential as a source of cosmetics ingredients.[9] With more than 250,000 different species described and many more waiting to be found, the oceans are home to a vast biodiversity. In recent decades, ocean exploration has made it possible to find a wide variety of habitats, often in harsh circumstances. The oceans are home to a diverse spectrum of species that generate an extensive array of active chemicals.[9, 10] Over 25,000 novel chemicals and biological activity have been found. Algae and bacteria are two of the main marine species that provide active substances. For instance, the cosmetics industry is very interested in the lipid content of microalgae. Lipids can make up as much as 90 % of the dry weight of certain species.[10, 11] Microalgae are also a source of pigments, specifically carotenoids (β-carotene, lycopene and cryptoxanthin), vitamins (A, B1, B2, B6, B12 and C) and phycobiliproteins (phycocyanin, phycoerythrins), as well as canthaxantin, astaxanthin and lutein. In addition to producing secondary metabolites such phenolic compounds, terpenoids, halogenated chemicals, derivatives of sulphur and derivatives of nitrogen, minerals, proteins, lipids and polysaccharides can all be found in macroalgae.[12, 13] Cosmeceuticals that act as UV filters, skin depigmentation, anti-inflammatory, anti-wrinkle, antiaging, skin moisturising, anti-acne, antioxidant and cytoprotective chemicals are in high demand right now (Figure-1).[13–15]

In the present review, a brief overview of the biological activities and underlying mechanisms of action of a few important cosmeceuticals is provided, along with the biochemical pathways and targets involved in these processes.

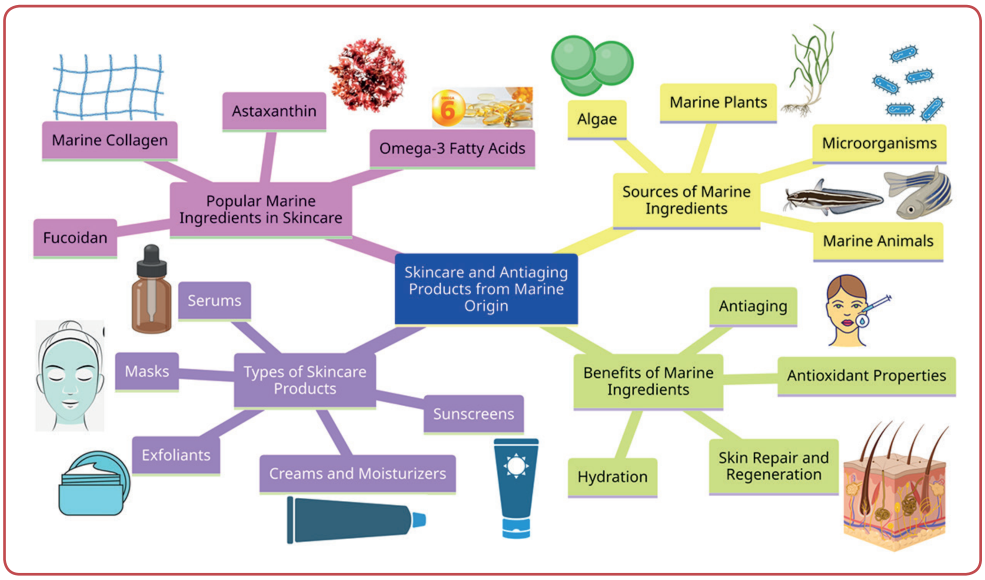

Figure 1: Overview of marine-derived products as skincare agents and associated cosmeceutical benefits

Marine-derived products as skin moisturisers

To maintain the integrity of the skin, the rate of hydration must be sustained. It is normal practice to apply lipids or compounds that prevent water loss topically. Marine organisms create a wide range of chemicals that have moisturising properties, such as polysaccharides, widely utilised skin-related proteins and fatty acids (sophorolipids, rhamnolipids and mannosylerythritol) (Figure-2).[16] Transepidermal water loss (TEWL) may generally be brought back to normal by consuming omega-6 polyunsaturated fatty acids, more especially linoleic and –γ linolenic acid, which have 18 carbon atoms. Water/oil emulsions are designed with occlusive substances that keep the water in the skin from being excessively lost.[17] While laminaria extracts are the preferred element in this context, several other algae can also be utilised. Notably, because of their high linolenic acid concentration, microalgae in the genus *Nannochloropsis* are particularly interesting.[11, 12] In addition, seaweeds high in serine, like *Thalassiosira microalgae* and *Undaria pinnatifida*, are particularly noteworthy.[13]

Collagen, found mostly in marine fish proteins, is commonly used in cosmetics due to its good moisturising qualities.[18] The moisturising and firming qualities of cosmetics derived from fish collagen have been evaluated. While cream formulas are effective when applied consistently, serum formulations offer superior moisturising benefits for a brief amount of time. With repeated use, the cream compositions seemed to become increasingly effective over time.[19, 20] In small amounts, collagen hydrolysates from jellyfish have also demonstrated potential as moisturising agents. They increase skin hydration and decrease TEWL.[21] Numerous bacterial species manufacture ectoine (1,4,5,6-tetrahydro-2-methyl-4 pyrimidinecarboxylic acid) as an osmoprotectant in response to osmotic stress. It was first isolated from *Undaria pinnatifida* Other halophilic bacteria that create ectoine include *Actinobacteridae*, alpha and gamma-proteobacteria and others, especially when exposed to high salt concentrations. Ectoine and other osmoprotectants, such as glycerol, have comparable capacities to bind water molecules. Topical administration of ectoine-formulated products is well tolerated by humans and have strong hydration qualities. Ectoine act as a long-term moisturiser that works well by keeping the epidermis hydrated. Research indicates that ectoine may be a potential treatment for moderate atopic dermatitis, as it reduces skin irritation. Thus, topical ectoine (EHK02-01) treatment could offer a new therapeutic option for patients with atopic dermatitis.[22]

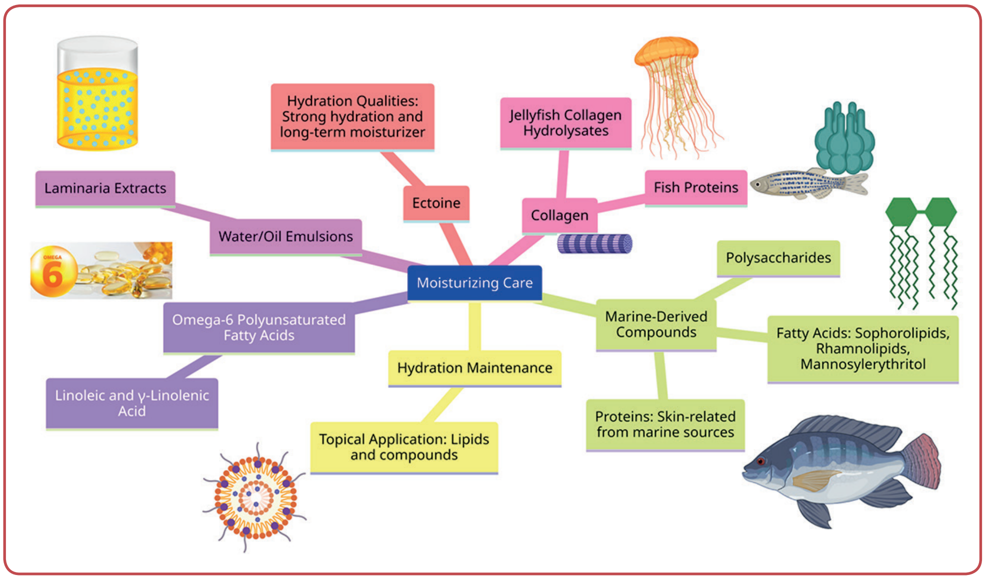

Figure 2: Marine-derived products for skin hydration and moisturising qualities

Marine-derived products as antiaging and physiological skin components

Degradation of the extracellular matrix in the dermal and epidermal layers is closely associated with aging skin. Environmental influences are also significant, but intrinsic (genetic) factors predominate. The latter include smoking, weather (wind exposure, for example) and ultraviolet (UV) exposure, whether from the sun or from a tanning booth.[23] Among the substances having anti-aging qualities, carotenoids are important active components. Carotenoids are yellow-orange liposoluble pigments made of eight carbon atom units with alternating single and double bonds that are generated from isoprene molecules. This pigment family is headed by β-carotene, which also has a strong ability to stop the production of reactive oxygen species (ROS).[24, 25] The halotolerant microalga *Dunaliella salina* primarily produces β-carotene, which can constitute over 10 % of its dry weight. Provitamin, β-carotene is also included in formulas for anti-aging treatment.[26]

The remarkable antioxidant capacity of astaxanthin, which outperforms that of α-tocopherol, is another factor that makes it useful for anti-aging treatment.[27] The highest natural source of astaxanthin is *Haematococcus pluvialis*, which is currently grown on an industrial scale and can accumulate above 3 grams of astaxanthin per kilogram of dry biomass.[28, 29] Additionally, new strains of marine bacteria from *Flavobacteriaceae* family have yielded two rare carotenoids, saproxanthin and myxol, which exhibit notable antioxidant effect. However, further research is needed before using them in cosmetic formulations.

One of the most popular classes of marine-derived bioactive chemicals with anti-aging characteristics is bacterial polysaccharides, or PSs. Microalgae are also producers of PSs. Isolating microorganisms from harsh settings like deep-sea hydrothermal vents has drawn more attention in recent years.[30, 31] PS has been shown to have emulsifying, thickening, absorption and gel forming qualities. Under the brand name "Abyssine", "Deepsane", a PS made from the marine bacteria *Alteromonas macleodii*, is already sold in cosmetics and is used to soothe and lessen skin irritation caused by UVB, mechanical and chemical aggression.[32] Anti-aging products have also been formulated using a mixture of PSs from *Pseudoalteromonas spp, Pseudoalteromonas antarctica* and *Halomonas eurihalina*, all of which are prevalent in Antarctic waters. This blend enhances the skin's structural properties by producing more collagen I.[33] The deep-sea bacterium *Vibrio diabolicus* generates HE 800, an exo-saccharide that can support collagen structure and is comparable to hyaluronic acid (Figure-3).[34]

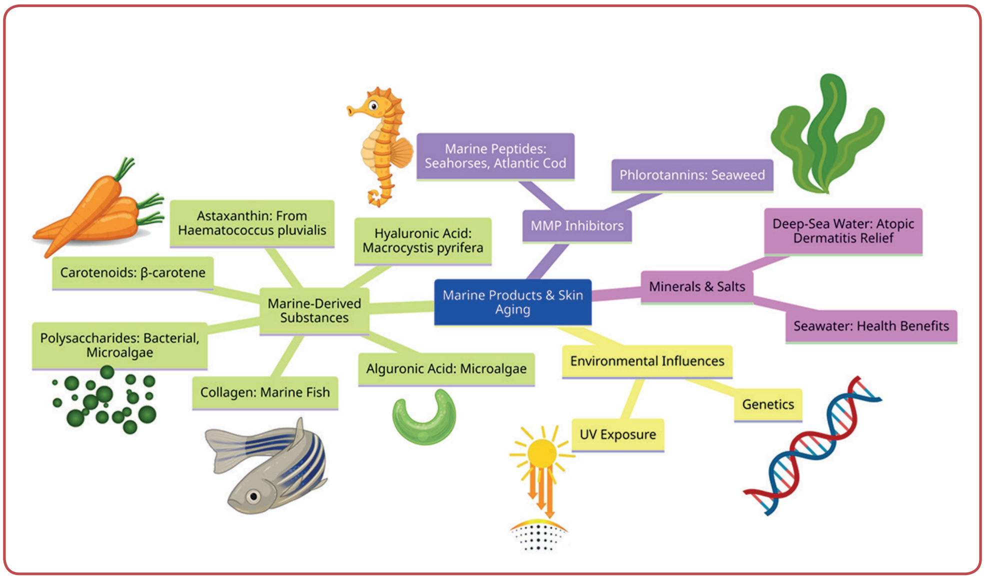

Figure 3: Marine-derived products for skin rejuvenation and anti-aging properties

Because of its superior skin-repair and re-generation qualities, collagen produced from marine fish is frequently employed in cosmetic compositions. The collagen derived from marine fish has a minimal odour and a better mechanical strength, despite coming from fish. It also has a greater capacity for absorption than collagen sourced from other animals.[35] Alguronic acid-derived formulations included in a Company's "Algenist" product line are a blend of polysaccharides generated by microalgae.[36] Alguronic acid would have demonstrated the capacity to encourage the production of elastin and accelerate cell renewal. Most likely nearby is "Alguard PF" (Frutarom), a polysaccharide was isolated from *Porphyridium spp* and suggested for the treatment of fine wrinkles.[37] In the area of anti-aging, an extract from *Chlorella vulgaris* also seems promising because it promotes the manufacture of collagen, one of the macromolecules that make up the dermis' extracellular matrix and which decreases with age and causes wrinkles.[38] Jania Rubens and *Meristotheca dakarensis* algae extracts are combined and sold commercially; the product is said to promote, synthesis of keratin, glycosaminoglycans (GAGs) and collagens I and III.[39, 40]

One important element of extracellular matrix of the skin is hyaluronic acid. Hyaluronic acid production inducers are frequently employed in anti-aging treatments. For this reason, an aqueous extract of the brown alga *Macrocystis pyrifera*, which belongs to the family *Laminariaceae,* is sold.[41] Another essential extracellular matrix protein, syndecan-4, may also be produced more readily when *M pyrifera* extract is used.[42] Wrinkles appear as a result of the ageing process, which also causes the skin to become thinner, less elastic and less curly.[43] Matrix metalloproteinase (MMP) inhibitors may prove useful as a cosmetic anti-aging product.

MMPs are Zn^{2+} extracellular endopeptidases that are secreted by a variety of cells, including macrophages, fibroblasts, mast cells, neutrophils and keratinocytes. The three primary MMP functional categories are described: interstitial collagenases (which breakdown type I, II and III collagen), strome lysins (which degrade fibronectin, laminin and proteoglycans) and gelatinases (which degrade type IV and V collagens).[44, 45] Their significance in the creation of wrinkles is significant.[46] Studies have indicated a connection between an increase in MMP production in fibroblasts and both photoaging and natural ageing processes. The cumulative effect of significant collagen breakdown by MMPs leads to wrinkles.[47] Marine sources are creative resources of MMPs inhibitors. Peptides obtained from marine fish have been shown to have the ability to inhibit MMP. It has been shown that by blocking collagenases 1, 3 and 13, peptides isolated from seahorses (SHP-1) encourage the release of collagen.[48] A gelatinase inhibitor resembling the human tissue inhibitor of MMP-2 (TIMP-2) is also produced by the muscle of Atlantic cod. Research has also been done on how marine-derived phlorotannins decrease MMP activity. The ability of several seaweed species to suppress MMP has been assessed. MMP-1 expression was significantly inhibited by the phenolic chemicals dieckol and eckol, which are produced from *E stolonifera*. Additionally, it has been shown that 6,60-bieckol from *Ecklonia cava* activates the NF-κB pathway, which significantly lowers the expressions of MMP-2 and -9.[49]

Seawater contains minerals that are known to have health advantages.[50] Especially good for the skin are the minerals (potassium, sodium, calcium, magnesium, sulphates and chlorides) found in sea water. Furthermore, sea salts are notable for their usage in skin-care cosmetics. Deep-sea water is thought to have favourable effects on atopic dermatitis as well as general and skin health in particular. The minerals in seawater and the quality of deep-sea water sources influence the health benefits.[51]

Marine-derived products as protectants against UV radiation

The skin is made up of three tissue layers that function as a physical and chemical barrier: the dermis, epidermis and hypodermis. Numerous environmental factors, including pollution, UV rays and chemicals, can damage skin. Dermatoheliosis, also known as photo-aging, is brought on by UVA (400 nm << 320 nm) and UVB (320 nm << 290 nm) radiation-induced skin damage.[52] Human skin may experience both immediate and long-term impacts from prolonged UV radiation exposure.[53] The consequences in the short term are largely favourable. The principal benefits include elevating mood, promoting vitamin D synthesis and providing immediate skin colouring. The drawbacks include tanning, thickening of the skin and actinic erythema. The long-term consequences are entirely detrimental and include UV radiation-induced immunosuppression, photo-carcinogenesis and photo-induced skin ageing.[54] Because of the severity of these long-term consequences, it is essential to use the proper protection when exposed to UV light. The comprehensive preventative plan includes both topical and clothing protection. Therefore, encouraging the active research in this field is essential to identifying novel compounds of interest (Table 1).

To defend themselves from UV radiation, a variety of marine organisms—most importantly those that are photosynthetic—produce UV-absorbing substances including carotenoids, mycosporines, scytonemins (cyanobacteria) and mycosporine-like amino acids (MAAs). Furthermore, not much research has been done on UV filters made by microbial components, despite their significant contribution to marine biomass and biodiversity. For this reason, a significant source of photo-protective chemicals is marine life.[55, 56]

Table 1: Summary of marine-derived products as topical skincare protect against UV radiation

Component	Source	UV protection type	Benefits
Carotenoids	Various marine organisms	Broad-spectrum (UVA and UVB)	Antioxidant properties, enhances skin defence
Mycosporines	Photosynthetic marine organisms	UVA protection	Absorbs harmful UV radiation
Scytonemins	Cyanobacteria	UVA protection	Shields against UV-induced damage
Mycosporine-like amino acids (MAAs)	Marine organisms including algae and cyanobacteria	Broad-spectrum (UVA and UVB)	High UV absorption, protects against photo-damage

Mycosporine-like amino acids

MAAs, which are soluble in water, are internal colourless compounds found in a wide variety of freshwater and marine animals. A nice example of a freshwater microalga that contains MAAs is *Aphanisomenon flos-aquae*. Cyclohexenimine chromophore or cyclohexanone makes up MAAs. Through imine connections, they are joined to the core, resulting in a mixture of resonating tautomers that absorb UV light. The UV spectrum between 310 and 362 nm is absorbed by MAAs and the energy is then released into the environment as heat radiation. Fungal, bacterial, cyanobacteria, phytoplankton and algae all synthesise MAAs. The position of these molecules within the cell affects how well MAAs defend against UV light.[57–59]

Scytonemin

Some cyanobacteria species have an extracellular sheath that contains the UVA-inducible pigment scytonemin.[60] Because of its superior absorption in this UV band, scytonemin can lower the quantity of UV-A radiation that reaches the cells by up to 90 %. It absorbs in the UV-B spectrum as well. Moreover, UVA-induced oxidative damage can start the creation of scytonemin.[61] Chemical structure of scytonemin is shown in Figure 4.

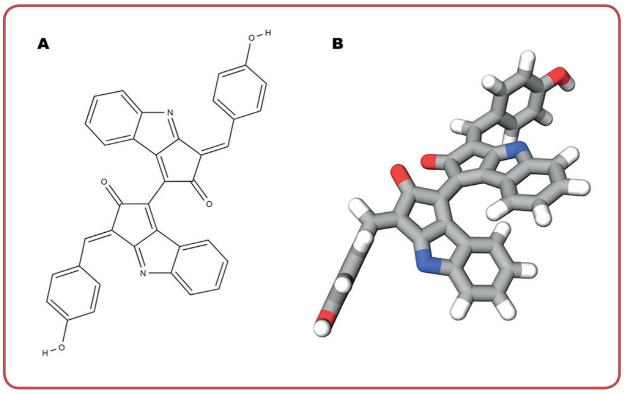

Figure 4: A. Scytonemin molecule B. 3D model of scytonemin

Marine-derived products as skin-whitening agents

The treatment of lentigo, pregnancy masks, residual hyperpigmentation and hyperpigmentation caused by excessive drug use are all major markets for whitening cosmetics. Tyrosinase is the primary enzyme involved in the synthesis of melanin and there is an active research for inhibitors of this enzyme.[62] While tyrosinase inhibitors derived from various natural substances, including marine sources, have already been used, some—such as hydroquinones—have been shown to be harmful to human health. Recent research has focused on identifying new skin-whitening compounds produced by marine microorganisms.[63]

Zeaxanthin, found in the extract of *Nannochloropsis oculata* appears to be most intriguing among them.[64] In terms of skin whitening, Codif's indicated chlorella extract would likewise reduce skin pigmentation by more than 10 %. Because of its anti-tyrosinase properties, phenoltannin 7-phloroeckol, which is extracted from *E cava* brown seaweed, has been suggested as a skin-whitening agent.[65] Little research has been done on marine bacteria as a potential source of compounds that whiten skin. But research revealed that human melanocyte pigmentation was decreased by the tyrosinase inhibitor methylene chloride, which is produced by the marine bacteria *Pseudomonas*. Additionally, it has been reported that thalassotalic acids, which are tyrosinase inhibitors and derivatives of N-acyl dehydrotyrosine, are produced by the marine bacteria *Thalassotalea sp* PP2-459, which was isolated from a bivalve. Another member of the carotenoids family with intriguing depigmenting abilities is astaxanthin. By lowering melanin production by 40 %, it would protect skin from age spots.[66] Research on marine skin-whitening molecules in cosmetics has fresh prospects because terrestrial organisms still supply the vast bulk of the skin-whitening compounds utilised in cosmetics. *Pistacia lentiscus* is a Mediterranean halophyte plant that has long been used medicinally. It grows best in salinity environments. *P lentiscus* leaves are rich in flavonoids and phenolic acids, including epicatechin, quercitrin gallate, gallic acid, β-glucogallin and catechin. Epicatechins, gallic acid and other catechins exhibit high tyrosinase inhibitory activity in *P lentiscus*, suggesting potential applications in the management of hyperpigmentation.

Marine-derived products as preservatives and additives in cosmeceuticals

Marine-derived products as preservatives

European Regulation (EC) 1223/2009 has an approved list of preservative agents for use in cosmetics in Annexe V (Table 2). Parabens are a class of antimicrobial chemicals whose safety has been called into doubt. Cosmetic items need to have preservatives added in order to avoid microbiological infection and to prevent modification.[3] It is crucial to create novel and secure antibacterial preservatives in this environment. Among the antimicrobial compounds obtained from marine settings, extracts from macro- and microalgae exhibit potential. Studies reveal that extracts from the macroalgae *Synechocystis spp* and *Himanthalia elongate* inhibit the growth of *Escherichia coli* and *Staphylococcus aureus*. Some activity was demonstrated by extracts from the microalgae *Isochrysis galbana, Dunaliella salina, Nannochloropsi soculata, Chlorella marina* and *Pavlova lutheri* against bacteria like *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*.[10] These early findings, meanwhile, are insufficient to envision using these extracts in industrial settings. The anti-microbial effect of chitosan against bacteria, viruses and fungus is clearly visible. This polysaccharide is composed of glucose and various amounts of GlcNAc residues that are generated from chitin, a polymer that is frequently found in fungal cell walls and the exoskeletons of marine arthropods.

Chloroform was used to extract the leaves of the halophyte *Crithmum maritimum* in order to create the polyacetylene falcarindiol. Falcarindiol strongly inhibits the growth of some bacteria, such as *Micrococcus luteus* and *Bacillus cereus*. As a result, *Crithmum maritimum* might be used as a preservative in the makeup sector. Furthermore, extracts from the leaves and fruits of another halophyte, *P lentiscus*, have been shown to exhibit antimicrobial action.

Table 2: Summary of Marine-derived products as preservatives and additives in cosmetic formulations

Component	Marine resource	Examples of compounds	Potential uses in cosmetics
Preservatives	Macro- and microalgae	Extracts from *Synechocystis* spp, *Himanthalia elongata, Isochrysisg albana*, etc.	Antioxidant properties, enhances skin defence
	Chitosan	Derived from chitin in marine arthropod exoskeletons	Antimicrobial against bacteria, viruses and fungi
	Polyacetylene	Falcarindiol from *Crithmum maritimum*	Inhibits growth of microorganisms like *Bacillus cereus*
	Cationic peptides	From half-fin anchovies (*Setipinnataty*) and Atlantic mackerel (*Scomber scombrus*)	Antibacterial in lotions, shampoos, creams
Essential oil	*Crithmum maritimum L*	Combination of dillapiole, camphor, p-cymene	Distinct aroma for cosmetic products
Antioxidant	Algae	Fucosterol, sulphated polysaccharides, phlorotannins, fucoxanthins	Natural antioxidants to protect skin from UV damage
	Carotenoids	Carotenes and xanthophylls	Anti-inflammatory and antioxidant in sunscreens

Cationic peptides often exhibit antibacterial properties due to their ability to interact with the membranes of microbial pathogens.[1] Currently, there is ongoing research into the cosmetic applications of antimicrobial peptides derived from marine species, including their use in products such as lotions, shampoos and moisturising creams.[10] The half-fin anchovies (*Setipinnataty*) pepsin hydrolysate yielded the HAHp2-3-I fraction, which was notable for containing five cationic peptides with promising antibacterial potential: MLTTPPHAKYVLQW, SHAATKAPPKNGNY, PTAGVANALQHA, QLG-THSAQPVPF and VNVDERWRKL The Atlantic mackerel (*Scomber scombrus*) has also yielded antibacterial isolates (SIFIQRFTT, RKSGDPLGR, AKPGDGAGSGPR and GLPGPLGPAGPK). They showed evidence of either complete or partial inhibition against bacterial strains classified as Gram-positive (*Listeria innocua*) and Gram-negative (*Escherichia coli*).

Marine-derived products as essential oil

Crithmum maritimum L, a halophyte plant, is found growing near beaches. The essential oil of *Crithmum maritimum* L has a distinct aroma due to a combination of ingredients: sandalwood (from dillapiole) and a trace of mustiness from camphor combined with lemon (from p-cymene) (Figure-5).[9]

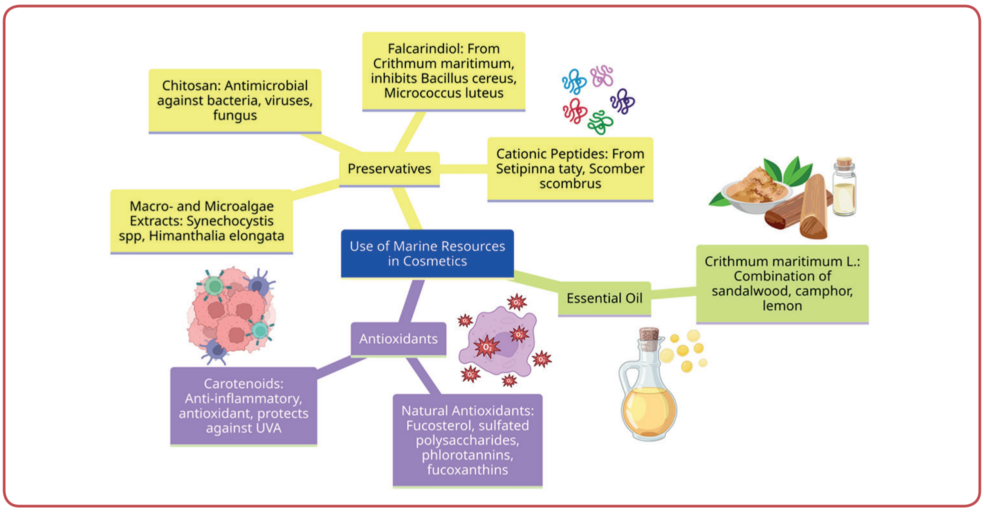

Figure 5: Marine-derived products as preservatives and essential oils used in cosmetic formulations

Marine-derived products as antioxidants

Antioxidants shield human skin against UV radiation from the pro-oxidative damage. Antioxidants shield human skin from UV-induced ROS that damage proteins, membrane lipids and DNA. These ROS include superoxide anion (O^{2-}) hydroxyl radicals (HO-) andhydrogen peroxide H_2O_2.[12] Notably, ROS-induced lipid oxidation contributes to the aging of skin. Synthetic antioxidants such as propyl gallate (PG), tertbutyl hydroquinone (TBHQ), butylated hydroxytoluene (BHT) and butylated hydroxyanisole (BHA) were used by the cosmeceutical industries to stop ROS-induced oxidation. However, because of the possible health risks, these artificial antioxidants should only be taken sparingly. Therefore, safe substitutes for artificial antioxidants in the cosmetics sector include natural antioxidants obtained from algae, such as fucosterol, sulfated polysaccharides, phlorotannins and fucoxanthins.[13] As organic pigments made up of eight isoprene molecules and forty carbon atoms, carotenoids are also known as tetraterpenoids. There are two categories for the more than 750 different forms of carotenoids that have been identified: xanthophylls, which include oxygen and carotenes, which are essentially hydrocarbons. They are generally produced from lipids by plants, certain bacteria and fungi.[19] Among other things, carotenoids are utilised in food supplements, colourants and cosmetics and nutraceuticals. Because they are antioxidants and have anti-inflammatory qualities, carotenoids are commonly found in sunscreen formulations. By lessening the toxicity of ROS, these characteristics aid in protecting the skin from UVA rays. Fungi, yeast and marine microbes are significant sources of carotenoids. For instance, several bacteria, including *Paracoccus* and *Agrobacterium*, as well as other yeast species—most notably, those belonging to the genera *Rhodotorula, Phaffia* and *Xanthophyllomyces*—produce astaxanthin. Although yeasts produce less carotenoid than algae, they grow faster, are easier to cultivate and can be genetically modified to increase carotenoid production rates.[20] Another important source of β-carotene is algae. Studies have been conducted on their potential as a source of β-carotene since the late 1960s. A green alga with only one cell, *Dunaliellais* a member of the genus *Dunaliella salina (Chlorophyceae*). As early as the late 1980s, *D salina* cultivation was improved to produce β-carotene on a commercial scale. It has been determined that high salinity and bright light yield the greatest -carotene synthesis (Figure-5). Moreover, the marine protist *Ulkenia sp* and related species like *Thraustochytriidae sp* AS4-A1 can generate carotenoids and antioxidants such astaxanthin (3,30'-dihydroxy-β,β-carotene-4,4'-dione) and docosahexaenoic acid (DHA).

In addition, marine halophytes contain phenolic chemicals that have potent antioxidant characteristics. Plant extracts' ability to function as antioxidants are typically closely correlated with their phenolic concentration. Thus, the high amounts of phenolic compounds found in *L salicaria* (278 mg GAE/g DW) may be responsible for its potent antioxidant action.[67] Elevated amounts of phenolic compounds have also been linked to increased oxidant activity in a variety of halophytes, including *Salicornia ramosissima, M edule, L monopetalum, T gallica* and *Limonium wrightii*. A halophyte of considerable interest is sea fennel (*Crithmum maritimum* L), due to its high number of secondary metabolites. The leaves of *C maritimum* are notable for their content of organic acids (malate and quinate), carbohydrates (sucrose and glucose) and phenolic compounds (particularly chlorogenic acid, or CGA). Chlorogenic acid demonstrates strong antioxidant properties. The amount of CGA that *Crithmum maritimum* L plants accumulate varies depending on the type of soil in which they grow. More CGA is accumulated by sand hill plants than by cliffside plants.[2]

Studies have also looked into the possibility of using peptides and proteins obtained from fish to protect skin from UV rays. Collagen and collagen hydrolysate from the skin of fish and jellyfish (*Rhopilema esculentum*) have been shown to have protective qualities against UV radiation.[5] This is particularly true when it comes to the antioxidant system (which includes superoxide dismutase and glutathione peroxidase). They inhibit photoaging by stimulating the synthesis of collagen and offering protection against the breakdown of skin lipids. Gelatine hydrolysate and collagen peptides have been shown to have a great ability to stop UV-induced inflammation, collagen degradation and the disruption of antioxidant enzyme systems in the skin.

Marine-derived products as dyes

One form of pigment found in algae and cyanobacteria is called phycobiliprotein and it has luminous properties that make it quite interesting. It is distinguished from other members of the phycobiliprotein family by a variety of hues that display different qualities.[68] The luminous red protein-pigment known as phycoerythrin (PE) emits light at $\lambda = 573$ nm and absorbs light at $\lambda = 498$ nm and 565 nm in the green and yellow light wavelengths, respectively. Phycocyanin, a blue pigment is an adjunct to chlorophyll and functions as an antioxidant and anti-radical. Furthermore, phycocyanin is a fluorescence-exhibiting substance that produces red light at 660 nm and absorbs red-orange light at 630 nm.[69] These days, the primary suppliers of phycocyanin and phycoerythrin, respectively, are the cyanobacterium *Spirulina platensis* and the red microalga *Porphyridium cruentum.* Due to the accumulation of marennine, a blue pigment soluble in water, in the apex of the cell, *Haslea ostrearia* displays a unique extra plastidial colour. Notably, oyster refining tanks contain this diatom. Oyster gills are fixed with the blue-green marennine pigment that gives them their distinctive green colour after ripening. Despite several biochemical characterisation tests, marennine's precise nature remains unknown. Marennine is neither a protein nor a carbohydrate, nevertheless, as evidenced by studies it is a polyphenolic compound.[70, 71]

Conclusion

Natural marine resources are still neglected, but cosmetic compositions made from them are definitely a powerful selling factor. The ever-expanding cosmetics and medicinal business may benefit from the possible uses of natural substances derived from the water environment. As a result, interest in a wide range of marine natural products has increased, particularly those made from marine bacteria and micro- and macroalgae. However, they are still far from reaching their full potential, especially for the marine creatures that reside in deep water and still require characterisation. To assure the efficacy and long-term safety of the relevant compounds for use in cosmetic applications, it will be important to undertake clinical trials and optimise the method of producing or extracting them once the appropriate species have been clearly identified.

Ethics

This study was a secondary analysis based on the currently existing data and did not directly involve with human participants or experimental animals. Therefore, the ethics approval was not required in this paper.

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Conflicts of interest

The authors declare that there is no conflict of interest.

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Data access

The data that support the findings of this study are available from the corresponding author upon reasonable individual request.

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