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The Potential of Seaweed Bioactives in Cosmeceuticals

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SUMMARY

The use of seaweeds for cosmetic and cosmeceuticals has become increasingly popular due to the demand for natural ingredients. Seaweeds have many advantages, including their renewable nature, wide distribution, and the abundance of valuable bioactive compounds they contain. These compounds, which include polyphenols, polysaccharides, proteins, peptides, amino acids, lipids, vitamins, and minerals, are responsible for the numerous biological properties associated with seaweeds. Seaweed fractions can also provide technical benefits, such as thickening, gelling, emulsifying, texturizing, and moistening, which can be used to create cohesive matrices. Additionally, the ability to use industrial waste streams and algal blooms makes seaweeds an attractive, low-cost, raw and renewable material. This review provides an updated summary of the activities of different seaweed compounds and fractions based on scientific and patent literature.

INTRODUCTION

It's interesting to note that consumer preferences towards green and eco-friendly products have increased in recent years, including in the cosmetics industry. This has led to a competitive and rapidly changing global market that demands natural, safe, and efficient ingredients for skincare products. One relatively new product that has gained attention is cosmeceuticals, which are active and safe products designed and tested by the cosmetics industry to benefit skin appearance and prevent and treat dermatologic conditions. These products incorporate a variety of active ingredients, including vitamins, phytochemicals, enzymes, antioxidants, and essential oils. One promising source of unique and active compounds for cosmetics, cosmeceuticals, and nutricosmetics is marine resources, particularly seaweeds. Seaweeds are a sustainable and renewable resource that can be used to create environmentally-friendly and sustainable ingredients for the cosmetic industry. Seaweed-derived ingredients have been found to provide a variety of skincare benefits, including photoprotective, moisturizing, antioxidant, anti-melanogenic, anti-allergic, anti-inflammatory, anti-acne, anti-wrinkling, antimicrobial, antiaging, and whitening. Additionally, seaweed extracts have low cytotoxicity and low allergen contents, making them safe for use in cosmetics and other products. The use of algal components within the cosmetics and cosmeceutical industries has been the focus of recent developments. The key activities of these components have been identified, emphasizing their significance in formulations. The benefits of seaweed-based additives have also been examined, including their textural, functional, and sensory properties. By drawing upon scientific literature and patented research, a variety of potential applications for algae and algal components have been presented, demonstrating the versatility and potential of these powerful ingredients.

Seaweed Components and its Bioactivities

Polysaccharides

Seaweeds have a crucial carbohydrate component in their cell walls called polysaccharides. Each type of algae has unique polysaccharides, such as alginate, laminaran, and fucoidan in brown algae, ulvan in green algae, and carrageenan in red algae, which is the most important. The popularity of these polysaccharides is growing because of their biofunctional and physicochemical features. Sulfated polysaccharides, in particular, are highly intriguing due to their health benefits and biological activities. Brown seaweeds contain alginates made up of d-mannuronic acid and l-guluronic acid, which have anti-allergic properties and can prevent obesity. Laminarin has prebiotic, antioxidant, anti-photoaging, and regenerative properties. Hydrogel systems made with laminarin sulfate can heal wounds and have potential in biomedical applications such as tissue engineering, cancer therapies, antioxidant, and anti-inflammatory properties. Fucoidans, which are non-toxic, biodegradable, and biocompatible, have potential as a cosmetic ingredient and can reduce antioxidant and antiradical properties. Green algae's sulfated polysaccharides, such as rhamnans, arabinogalactans, galactans, and mannans, have

variable compositions and structures. Ulvans from ulvales have a variety of activities such as gelling and anti-aging. Agar, carrageenans, and porphyran have pharmaceutical and industrial cosmetic applications. Agaro-oligosaccharides (AOS) and carrageenan-oligosaccharides (COS) have enhanced biological properties compared to native ones related to their chemical structure, molecular weight, degree of polymerization, and the flexibility of the glycosidic linkages, such as prebiotic, antitumoral, and antioxidant actions.

Proteins

Seaweeds are a rich source of proteins, offering a higher protein yield per unit area than terrestrial crops. However, extracting these proteins can be difficult due to the presence of polysaccharides, such as alginates in brown seaweed or carrageenans in red seaweed. The protein content of seaweed varies depending on the season and habitat, with red algae having the highest concentration of essential and non-essential amino acids. Seaweed proteins and bioactive peptides have many health benefits, including high antioxidant properties, and are considered safer than synthetic molecules with reduced side effects. Bioactive peptides typically contain 3 to 20 amino acid residues and have activities such as antioxidant and antimicrobial effects. Mycosporine-like amino acids (MAAs) are synthesized for protection against solar radiation, with some MAAs showing antioxidant, anti-inflammatory, and anti-aging properties. Phycobiliproteins are water-soluble compounds that can be used as natural colors in food, pharmaceuticals, cosmetics, and textile industries. Phycobiliproteins extracted from *Gracilaria gracilis* have high antioxidant and radical scavenging activities, while R-phycoerythrin extracted from *Furcellaria lumbricalis* and *Coccotylus truncatus* is correlated with collection depth.

Phenolics and Terpenoids

Phenolic compounds are naturally occurring substances found in plants that serve as part of their defense mechanisms. These secondary plant metabolites have a basic structure with one or more aromatic rings and one or more attached -OH groups. Phlorotannins are a type of secondary metabolite that are structurally less complex than terrestrial tannins and are found in polymerized structures with ether, phenyl or 1,4-dibenzodioxin linkages. Phlorotannins have been found to have antioxidant, anti-allergic, anti-inflammatory, tyrosinase inhibitory, and antidiabetic properties, making them increasingly popular for use in cosmeceutical applications. They have been shown to protect against skin damage caused by UV radiation and to attenuate the expression of MMP-1, which is responsible for the degradation of dermal collagen in human skin aging. Dioxinodehydroeckol from *Ecklonia cava* proved to be an effective repair agent for skin damage against UVB. On the other hand, fucofuroeckol-A derived from the brown seaweed *Ecklonia stolonifera Okamura*, exhibited protective activity against UVB radiation; other studies also exhibited similar results for eckol and dieckol. Meroterpenoids have also been found to have antioxidant and photodamage attenuation properties, making them useful for the prevention of skin photoaging.

Lipids

Seaweed is known to have a low lipidic content, typically less than 5%, but it is highly unsaturated and has a favorable ω3:ω-6 fatty acids ratio. The most abundant fatty acids in seaweed are γ-linolenic acid, arachidonic acid, eicosapentanoic acid, and docosahexanoic acid. Other lipids such as sterols and phospholipids are also found in seaweed. Fucosterol, isofucosterol, and clionasterol are the main sterols found. Lipids have various biological properties, including a positive effect on skin barrier protection and other biological functions. Polyunsaturated fatty acids (PUFA) can contribute to nutricosmetics and aid in anti-obesity and regulation of inflammatory responses. Sterols, being structural components of cell membranes, regulate membrane fluidity and permeability while also providing antioxidant, antiproliferative, anti-photodamage, and anti-inflammatory effects. Fucosterol has been found to be effective against the malarial parasite Plasmodium falciparum. Phospholipids have been reported to assist with carotenoid absorption and reduce body weight and fat mass. Seaweed essential oil has also been evaluated, with red seaweed *Portieria hornemannii* essential oil exhibiting antimicrobial and anti-dandruff properties. An antibacterial film was created with a carrageenan biopolymer blended with extracted seaweed essential oil, which showed adequate bio-physical, mechanical, and anti-microbial properties.

Vitamins

Vitamins are crucial for healthy skin and can be obtained through diet and topical application. They guard against dehydration, premature aging, and sun damage while regulating oil production and maintaining

skin structure. The most important and clinically validated vitamins for skin photoaging prevention and treatment are vitamins A, C, E, K and vitamin complex B. Vitamin A, or the retinol form, has antioxidant and antiwrinkle capacity and is often used in cosmetics to reduce facial hyperpigmentation and fine wrinkles. The concentration of vitamin complex B (B1, B2, B3 or niacin, B6, B9 or folic acid, B12) is generally higher in green and red seaweeds, and vitamin B3 active forms added to skin care products include niacinamide, nicotinic acid, and nicotinate esters. Niacinamide is an antioxidant that reduces hyperpigmentation and improves aspects of the epidermis by reducing trans-epidermal water loss. Vitamin C, specifically l-ascorbic acid, is commonly used in the cosmeceutical industry and has antioxidant, detoxifying, antiviral, anti-inflammatory, antimicrobial, and anti-stress effects. It can also enhance tissue cell growth, repair blood vessels, teeth, and bones. Studies have shown skin improvements in fine lines and reduction of pigmentation and inflammation with the appropriate concentration of vitamin C in a cosmetic formula. Vitamin E, specifically α, γ, and δ tocopherol, is the most abundant fat-soluble vitamin of non-saponifiable lipids in many algae. It can effectively protect against UV damage, photoaging, and skin cancer when in a high concentration and non-esterified form. Vitamin K, found in high concentrations in some seaweeds, has well-known blood clotting properties and is effective in wound, bruise, mark, and scar healing.

Minerals

Seaweeds are known for their high mineral content, which can range from 8% to 40%, depending on the species, geographical location, and environmental factors. Seaweeds are an excellent source of both macro and trace elements, including calcium, iron, zinc, iodine, and selenium. These minerals have been found to be essential for maintaining good health and well-being. In fact, seaweeds are considered to be an ideal natural source of minerals. In addition to their health benefits, seaweeds are also used in cosmetics and skin care products. Mineral sea salts derived from seaweed are particularly effective in skin care products because they have a high affinity to human skin and are rapidly absorbed. These products are used for their therapeutic properties in treating skin-related disorders such as psoriasis, as well as for their beneficial effects on the skin, including anti-aging effects, acne repair and prevention, and improved blood circulation. Seaweeds have also been found to help retain water in the skin for longer periods of time and restore skin pH. Ultimately, seaweeds are a safe and natural source of minerals that have numerous benefits for both health and beauty.

Pigments

Seaweeds can be classified into three groups based on the concentration of pigments: green, brown, and red. The brown seaweeds contain carotenoids, which are isoprenoid molecules produced by photosynthetic plants, fungi, and algae. These lipophilic compounds act as colors in foods and as natural color enhancers in the food, pharmaceutical, and cosmetic industries. Carotenoids have attracted considerable interest due to their antioxidant and anti-inflammatory properties. Fucoxanthin is the main carotenoid in brown algae and is responsible for various anti-melanogenic, anti-aging, and antioxidant activities. This xanthophyll can counteract oxidative stress caused by UV radiation and suppresses tyrosinase activity in UVB-irradiated guinea pig and melanogenesis in UVB-irradiated mice. Additionally, fucoxanthin enhances the fat burning rate of fat cells in adipose tissue and might be used to treat obesity and reduce the risk of certain disorders.

CONCLUSION

Cosmetics and cosmeceuticals, have become increasingly popular for enhancing the appearance of skin and treating various dermatologic conditions. Seaweeds are an excellent source of valuable components for creating these products due to their diverse functional, sensorial, and biological properties. Extracting vitamins, minerals, amino acids, carbohydrates, and lipids from seaweeds can lead to the development of both conventional and innovative cosmeceutical products. The renewable and versatile nature of seaweeds allows for a vast array of activities to be offered, making them an attractive resource. However, it is important to consider extraction and purification processes, as well as greener methods of extraction, chemical and biological characterization, and stabilization and delivery into new products. Quality control and standardization are also necessary for the commercial use of seaweed bioactives, just like with any other ingredient or application.

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