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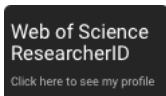
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**BENEFICIAL EFFECTS OF MARINE ALGAE IN SKIN MOISTURIZATION AND
PHOTOPROTECTION**

HARESH S. KALASARIYA, DR. MEHUL P. DAVE, DR. VIRENDRA KUMAR YADAV AND DR.
NIKUNJ B. PATEL

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BENEFICIAL EFFECTS OF MARINE ALGAE IN SKIN MOISTURIZATION AND PHOTOPROTECTION

Haresh S. Kalasariya¹, Dr. Mehul P. Dave², Dr. Virendra Kumar Yadav³, Dr. Nikunj B. Patel*

^{*,1}Department of Microbiology

Smt. S. S. Patel Nootan Science & Commerce College,
Sankalchand Patel University, Visnagar-384 315

²Life Science Department, Indian Institute of Teacher Education, Gandhinagar

³School of Life Sciences, Jaipur National University, Jaipur, Rajasthan

¹hareshahir22@gmail.com,

²drmeihulpdave@gmail.com, ³yadava94@gmail.com, * niks17micro@gmail.com

ABSTRACT

Among marine organisms, marine algae are rich sources of diversified bioactive constituents with various potential biological activities. It contains many natural phycochemicals such as polysaccharides, fatty acids, amino acids, vitamins, minerals, phenolic compounds, etc. that are utilized for various industrial applications. Nowadays, seaweed received great attention in cosmeceutical applications for skin health benefits. It exhibits a wide range of biological activities in cosmetics such as skin whitening, moisturizer, photoprotection, antiwrinkle, antiaging, antimicrobial activities, etc. The present review study aims to check the applicability of marine macroalgae in moisturizing the skin and protection of the skin against UV damaging effects. This overview further helpful in the evaluation and development of marine algae in cosmeceuticals applications.

Keywords: Cosmetics, Marine macroalgae, Photoprotection, Phytochemicals, Skin moisturizer

Corresponding Author: Dr. Nikunj B. Patel

INTRODUCTION

Algae are a class of photosynthetic organisms found in marine as well as freshwater habitat.¹ It contains diversified photosynthetic pigments that are helpful to prepare food for themselves.² Mainly algae are of two types: Macroalgae and Microalgae. The former one is similarly known as seaweed, multicellular eukaryotic photosynthetic organisms belong to Plantae kingdom.^{3, 4, 5} It is macroscopic, benthic, and up to 50 meters in length. Normally, it can be divided mainly into three types: red algae (Rhodophyta), green algae (Chlorophyta), and brown algae (Phaeophyta).² Algae are found in shallow water, in the tidal, subtidal or intertidal zone. It is found anchoring with rocks, corals, shells, pebbles, sand, plants, or in floating form.⁶

Marine algae possess a huge pigment diversity such as red algae contain chlorophyll a, chlorophyll b, phycobilins, r-phycoerythrin, carotenoids, lutein, B-carotene, etc. Along with brown algae possess chlorophyll a, chlorophyll c, carotenoids, fucoxanthin whereas green algae contain green pigment such as chlorophyll a and b, carotenoids, etc.⁷

Marine macroalgae are widely distributed along the coast of India as well as Gujarat coastal line. The Indian coastline is about 7500 km long and many different sites such as Mandapam, Vishakhapatnam, Kerala, Thiruvananthapuram, Ramnathpuram are a rich source of seaweed diversity.^{8, 9} The coast of Gujarat comprises two gulfs namely the Gulf of Kachchh and the Gulf of Khambhat. Both the Gulf showed huge varieties of different marine algal species in various regions such as Okha, Veraval, Beyt Dwarka, Mandavi, Bhavnagar (Ghogha, Gopnath, Bhavani), etc.^{10, 11, 12} Marine macroalgae rich in nutritional components such as primary and secondary metabolites. It is rich in carbohydrates, proteins, lipids, amino acids, mycosporin amino acids (MAAs), fatty acids, phenolic compounds, sterols, pigments, minerals, and vitamins.¹³ Due to the rich diversity of such novel constituents, it is a widely underexplored resource of the designing and production of novel products. With over increasing life expectancies among people around the world, the physical appearance of skin concern is increasingly becoming a common cosmeceutical approach.¹⁴ Cosmetics are the preparation of some ingredients to enhance, to improve, or alter the function and appearance of the skin.¹⁵ Nowadays, Peoples are more attentive to the formulation of anti-aging, skin whitening, photoprotection, moisturization, etc.¹⁶

Instead the huge demands of cosmetic products by people encouraging the future of the cosmetic industry. To satisfy the customer's requirements, industries are trying to develop many cosmetic products with some synthetic ingredients. Many synthetic chemicals have been used in formulations such as PHA, PHB, Oxybenzone, BHA, BHT, DEA, MEA, etc.¹⁶ These types of chemical constituents accumulate in the skin layers and cause some damaging effects such as dermatitis, Dryness, skin blotches, white patches, cancer, wrinkle formation, etc.^{17,18,19} The overexploitation market for skin products and continual search for innovative ingredients have led to the development of natural products.²⁰ To overcome these harmful effects as well as in search of an alternative, Marine algae is widely used as a natural source of bioactive compounds for functional cosmetic applications.²¹ Seaweed phycocomponents such as carbohydrates, sulfated polysaccharides, fucoidan, carrageenan, oligosaccharides, terpenoids, carotenoids, tocopherol, phenolic compounds, phlorotannins, carrageenan oligosaccharides, crude polysaccharides needful for imparting many biological activities such as antioxidant, anti-inflammatory, anti-tumor, anti-allergic, antimelanogenesis, anti-skin-aging, anti-atopic dermatitis, anti-skin cancer, anti-oxidative photoprotection, etc.^{22,23,24,25,26,27,28,29,30,31}

Skin is the main sensory organ of the human body and its properties get damaged by overexposing of Ultraviolet (UV). UV radiation is harmful to skin as well as forms ROS (Reactive oxygen species). It also proved to be mutagenic, carcinogenic and dehydrates the skin. These problems required a lot of attention to natural alternatives.³² There are many marine algae-derived bioactive compounds such as squalene, polysaccharide, proteins, phenolic compound helpful in skin curation, and revealed treating effects against skin inflammation, dehydration, skin-soothing, photo damaging activity, etc.^{33,34,35,36,37,38,39}

Water is essential for skin characteristics such as flexibility, normal functioning such as maturation and desquamation of the skin.⁴⁰ Flynn et al. (2001) suggested Stratum Corneum (SC) can hold water (20-35%) and acts as a barrier to prevent loss of water.⁴¹ According to them, less than 10% of water content create roughness and dryness of the skin. This problem creates attention towards maintaining water holding capacity will improve flexibility and normal functions of the skin.⁴² Some synthetic humectants increase trans epidermal water loss or create toxicity. Another alternative such as natural humectants contains MAAs, polysaccharides, lipids, proteins, etc. helpful in such activities.^{43,44,45} Due to the harmful effect of UV radiation on the skin, leading to dryness or dehydration and reduce the elasticity of the skin.⁴⁶ Due to the negative consequences of using chemical ingredients,

there are many species of marine algae showed the presence of potential metabolites that responsible for moisturizing the skin or act as a UV filter.⁴⁷

REVIEW ON MOISTURIZING ACTIVITY

Varsha Vaibhav and Sangeeta Sahasrabudde, (2018) suggested various beneficial applications of macroalgae including cosmetics such as in the treatment of skin aging, tanning, prevention of roughness, skin wrinkles, whitening, and antibrowning reaction.⁴⁸ Valentina Jesamani et al. (2019) reviewed on potential uses of seaweed bioactive compounds in skincare such as hyperpigmentation, premature skin aging, acne, photoprotection, etc.¹⁵ Carbohydrates for skin health-beneficial to the skin such as antioxidant, anti-melanogenic, skin antiaging, etc.⁴³ Bioactive compounds of marine algae play their role in skin hydration and protection.^{49,14} Marine algae as a natural source(safer and equally effective) to enhance skin appearance by moisturizing and protecting against damaging UV rays.^{50,51} Extract of seaweed *Laminaria japonica* extracts on skin moisturization checked in vivo by Surbhi Joshi et al. (2018). It possesses a promising ingredient which can be useful for this activity.⁵² Snezana Agatonovic-kastrin and David W Morton, (2013) reported the presence of bioactive compounds (such as terpenoids, polysaccharides-fucoidan, carrageenan, alginates, etc.) and its activity in skin moisturization.⁵³ Different marine algae are used for studying its application in skin moisturization by various researchers as revealed in table no.1.

REVIEW ON PHOTOPROTECTION ACTIVITY

Brown algae showed strong inhibition activity on UV-induced MMP-1 (Matrix-metalloprotein complex) expression lead to photoprotection.⁵⁴ Phycocomponents of *Ecklonia stolonifera* such as dieckol and eckol inhibit the expression of MMP-1 in the human dermal fibroblast cell line.⁵⁵ Besides, phlorotannin that present in many marine algal species that interfere with the expression of NF-KB and AP-1(activator protein-1) which inhibits the expression of the same complex.⁵⁶ Sometimes, extracellular degradation occurs by MMPs. that require attention towards MMP inhibition. Kim et al. (2011) suggested the role of polysaccharide in reducing the risk of photoprotection by binding with Fibroblast growth factors and protect them from proteolysis.⁵⁷ Some other findings revealed the role of polysaccharide in the minimization of human skin fibers against proteolysis.⁵⁸ Table 2 illustrates the review study on the applicability of marine algae in photoprotection.

CONCLUSION

This review study provided the various biological activities of different marine macro algae-derived phycosubstances. Mainly, this work focusing on two activities: Skin moisturizing and Photoprotection. Seaweeds are richer in carbohydrates, proteins, fatty acids, etc. that worked as a humectant and this can be helpful to hydrates the skin, prevent skin to become rough and flaccid. Another application focused on the protection of the skin against UV-induced damages that is photoprotection. It is possible by inhibiting Matrix Metalloprotein(MMP) activity. Therefore, further investigations should elicit the precise molecular basis of phycocompounds for biological activities as well as understanding the role of marine macroalgal compounds, and their skin benefits would help to contribute to developing novel cosmeceutical preparations.

Table 1: Skin moisturizing effect exhibited by different marine algae

No.	Name of Algae	Activity	References
1	<i>C.tomentosum</i> <i>A.nodosum</i>	Skin moisturization	59,60
2	<i>Ulva lactuca</i> <i>Ulva rigida</i> <i>Ulva rotundata</i>	Skin Moisturizing	61,62
3	<i>Durvillea species</i>	Skin Moisturizing	63,64
4	<i>U.pinnatifidia</i>	Skin moisturization	59,60
5	<i>C.crispus</i>	Skin moisturization	59,60
6	<i>Cladosiphonokamuranus</i>	Skin moisturization	65
7	<i>Durvillea antarctica</i>	Skin moisturization	66
8	<i>P.palmata</i> <i>P.umbilicalis</i>	Skin Moisturizers	67,68
9	<i>Vertebrata lanosa</i>	Skin moisturizing	59,60
10	<i>S.japonica</i> <i>Chondrus crispus</i> <i>Codium tomentosum</i>	Skin moisturization	69
11	<i>Laminaria japonica</i>	Skin moisturizing effect	70
12	<i>Rhizocloniumhieroglyphicum</i>	Moisturizing effect on skin	71
13	<i>Nostoc commune</i>	Skin Moisturizing	48
14	<i>F.vesiculosus</i>	Smoothing and skin conditioning properties	72
15	<i>Ulva australis</i>	Moisturizers	73,74
16	<i>Ulva compressa</i>	Smoothing face cream	75,76
17	Genus <i>Nannochloropsis</i>	Skin moisturizing	77
18	<i>Gracillaria species</i> <i>Monostroma species</i>	Skin Moisturizing	78,79,80,81
19	<i>Laminaria japonica</i>	Skin moisturizing activity	52
20	<i>Dunaliella salina</i>	Improvement of the skin roughness	43

Table 2: Photoprotection effect revealed by different marine algae.

No.	Name of Algae	Activity	References
1	<i>Tetraselmissuecica</i>	Photoprotective activity	82
2	<i>Catenella repens</i> (Red algae) <i>Chlamydomonas hedleyi</i> (Green algae) <i>Padina crassa</i> (Brown algae)	Photoprotection (absorb UV radiation)	83,84
3	<i>Chlorella sorokiniana</i>	Photoprotection/Anti Photoaging	85
4	<i>Porphyra species</i>	Photoprotection	86
5	<i>Ulva lactuca</i> <i>Ecklonia cava</i>	Photoprotection	87
6	<i>Chlorella zofigiensis</i>	Photoprotection	88
7	<i>Sargassum aquifolium</i> <i>S.cristaeifolium</i> <i>S.polycystum</i>	Antiultraviolet	89
8	<i>U.lactuca</i> <i>U.rotundata</i> <i>U.rigid</i>	Protective agent	90,91
9	<i>A.nodosum</i> <i>E.cava</i>	UV Screens	92,93,94, 95

<i>C.pilulifera</i>			
10	<i>L.okamurae</i>	UV protection	96
11	<i>U.pinnatifida</i>	UV protection	97
12	<i>P.umbilicalis</i>	Sunscreen formulation	98
13	<i>Porphyrayezoensis</i>	UV protection	99
14	<i>Spirulina sp., Chlorella sp., Dunaliella sp.</i>	Reduce UV induced damage	100
15	<i>Fucus serratus</i>	Protecting agent	101
	<i>Porphyratenera</i>	Photoprotective activity	
16	<i>Tetraselmisuecica</i>	Sunscreen	102
17	<i>Sargassum species</i>	Sunscreen cream	103
	<i>Eucheuma cottonii</i>		
18	<i>Sargassum species</i>	Photoprotective activity	104
	<i>Turbinaria species</i>		
	<i>Padina species</i>		
19	<i>Halidryssiliquosa</i> (Brown macroalga)	Sunscreen	105
20.	<i>Ulva australis</i>	Natural sunscreen	67,68
21	<i>Sargassum species</i>	Sunscreen cream	106, 107
		Anti-ultraviolet ray	
22	<i>Porphyrayezoensis</i>	UV protection	108

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