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ALGAL PIGMENTS AND ITS APPLICATIONS -A REVIEW

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ABSTRACT :

The natural source of commercially useful bioactive pigments has been found in algae. Algal pigments capture solar energy and are used for photosynthesis. Chlorophylls, phycobilins, and carotenoids are the three main types of algal pigments. For the antioxidant, anti-inflammatory, immunoprophylactic, and anticancer qualities, many common carotenoids are employed, including astaxanthin, lutein, fucoxanthin, canthaxanthin, zeaxanthin, and –cryptoxanthin. Algal pigments have positive effects on health, but they are also very useful economically as natural colorants in the nutraceutical, cosmetic, and pharmaceutical sectors. Uses of these natural coloring substances in the food, cosmetics, and diagnostics sectors are outlined in this article.

KEYWORDS:*Algal pigments, Phycoerythrin, Phycocyanin, Chlorophyll,Fucoxanthin, Extraction of algal pigments, Cancer studies, Cosmetics, Food industry ,Textile, Pharmaceuticals*

INTRODUCTION:

The importance of colorings and coloring agents derived from natural sources is significantly increasing as a result of environmental and health concerns. There are many different photosynthetic pigments seen in algae. Natural colorings have really been used to color and print fabrics since ancient times[1,2]. Natural dyes and coloring agents are favorable to the environment and have recently gained significant attention because of concerns about human health and the environment. Natural colorings are pigments derived from mineral, animal, or artificial sources. They may be obtained from any area of the factory, such as leaves, fruits, outgrowths, seeds, flowers, dinghy roots, etc. [3,4]. A great deal of interest has recently grown in the commercial use of algae, which is based on its priceless bioactive compounds and activities in a variety of fields including food, decorative, agri- and horticultural industries, as well as human health. Colors, proteins, lipids, and polysaccharides are among the bioactive composites of particular interest[5]. Only specific visible light wavelengths are reflected by the chemical compounds that make up colors. They seem different because of this. The capacity of colors to absorb particular wavelengths of light is more significant than how they reflect light. Algae must create a variety of colors in order to catch more of the sun's energy since each hue only responds with a certain range of the diapason. Chlorophyll, Xanthophyll, Fucoxanthin, Phycocyanin, and Phycoerythrin are the pigments present in algae[6,7]. Several experimenters have recently looked at how natural colors work as UV and antibacterial agents in achromatic fabrics. The employment of natural colorings rather than synthetic colorings might provide a different outcome, yet most natural colorings are valuable since birth is typically valuable. This necessitates the search for improved natural colorings that are reliable and have a very simple birth procedure. [8,9]. Algal pigments might be useful for this and have the additional bonus of having some antibacterial activity. In order to hinder algae's ability to fight off microbes and provide natural color, an exploration was therefore suggested [10].

CLASSIFICATION OF ALGAE AND ITS PIGMENTS [11,12,13,14]:

DIVISION	COMMON NAME	ACCESSORY PIGMENT
Chlorophyta	Green algae	Chlorophyll b
Euglenophyta	Euglenoids	Chlorophyll b
Phaeophyta	Brown algae	Chlorophyll c1 +c2
Phaeophyta	Brown algae	fucoxanthin
Chrysophyta	Yellow- brown or golden- brown algae	Chlorophyll c1 +c2
Chrysophyta	Yellow- brown or golden- brown algae	fucoxanthin
Pyrrhophyta	Dinoflagellates	Chlorophyll c2
Pyrrhophyta	Dinoflagellates	Peridinin
Crptophyta	Cryptomonads	Chlorophyll c2
Crptophyta	Cryptomonads	Phycobilins
Rhodophyta	Red algae	Phycoerythrin
Rhodophyta	Red algae	Phycocyanin
Cyanophyta	Blue- green algae	Phycocyanin
Cyanophyta	Blue- green algae	Phycoerythrin

ALGAL PIGMENTS:

- **CHLOROPHYLL**:

In order to achieve its essence complicated color, chlorophyll, also known as splint herbage, is a porphyrin outgrowth with magnesium as the core component. It is the catalyst for photosynthesis and is found in the chloroplasts of every green store corridor. It is a blend of the blue green chlorophyll a and the unheroic green chlorophyll b. In lacustrine algae, chlorophyll c is present, and in red algae, chlorophyll d [15]. For coloring mineral canvases, waxes, essential canvases, and ointments, as well as dyeing and bleaching canvases and detergents, chlorophyll found in fats and canvases is employed. Chlorophyll compounds that are water-soluble are used in a variety of food items, such as gelatin goods, confections, and beverages, to provide color. They are included in detergents and cremes for use in cosmetics. All types of algae, including advanced storage and cyanobacteria, have chlorophylls, which are green, lipid-responsive pigments that facilitate photosynthesis. Topheophytin, pyropheophytin, and pheophorbide are the products of the conversion of chlorophyll in plant food[16].

i) CHLOROPHYLL a

The primary pigment for photosynthetic processes is chlorophyll a. Every type of plant, as well as algae, bacteria, cyanobacteria, and phototrophs, contain it.It absorbs orange-red and violet-blue light spectrums. Blue-green color serve as its reflective color. Its molecular formula is C55H72MgN,O5. 839.51 g/mol is the molecular weight. [17]. Chlorophyll a serves as the electron transport chain's primary electron donor, which is its primary function. Future solar energy will someday be transformed into chemical energy that the body may utilize for biological operations. Between 30 nm and 660 nm, it absorbs light. CH3 side groups exist on the porphyrin ring. [18].

ii) CHLOROPHYLL b

An important auxiliary pigment is chlorophyll b. Only plants and green algae contain it. It takes in spectral orange-red light. A yellow-green hue serves as the reflective color. The main purpose of chlorophyll B is to broaden the range of organisms that can absorb light. This increases the amount of energy that organisms can absorb from high-frequency blue light. Chlorophyll B in cells aids in the conversion of more solar energy into chemical energy in living things**.** [19]. Cell chloroplasts have more chlorophyll, which is adaptive. The amount of chlorophyll B in a plant's chloroplasts increases as the amount of sunlight decreases. As a result of being able to absorb a wider spectrum of light wavelengths, an increase in chlorophyll B is a shade-adapted adaptation. The surplus energy is sent from chlorophyll B to chlorophyll A. The atomic structure is $C_{55}H_{70}MgNO_6$. 907.9 g/mol is the atomic weight. Between 50 to 650 nm, it may absorb light. Another group than CH_3 exists in the porphyrin ring. [20].

iii) CHLOROPHYLL c

A majority of algae contain chlorophyll c pigment. Chlorophyll c is found in diatoms, dinoflagellates, and brown algae. A porphyrin ring is present, making it a peculiar chlorophyll pigment. Chlorophyll c1, c2, and c3 are further subclassifications of it. Different chemical make-up and absorption rates differentiate each subtype [21]. Normal chlorophyll c is known as chlorophyll c1. In contrast to chlorophyll c2, which possesses an ethyl group rather than a vinyl group (a C-C single bond rather than a C=C double bond), it is different from chlorophyll c2. In acetone and diethyl ether, its absorption maxima are respectively at 577, 626 nm and 579, 629 nm. Chlorophyll C is a green pigment with the chemical formula $C_{36}H_{28}MgNO_7$ and a molecular weight of 652.96 g•mol-1[22].

- **FUCOXANTHIN**

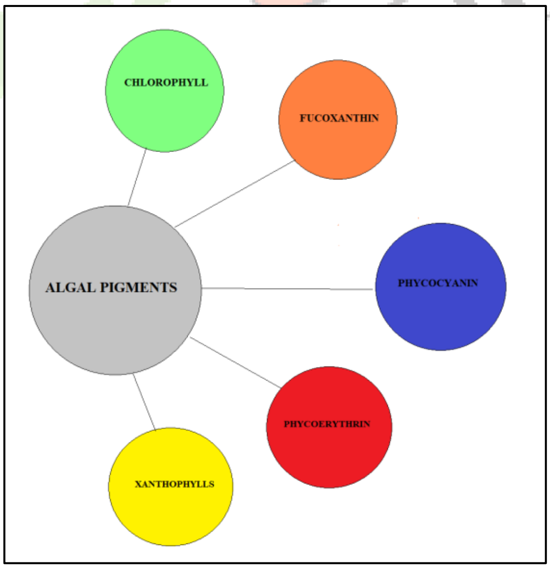
A pigment found in seaweed or phaeophyceae species is called fucoxanthin. 2000 different marine species can be found there. This is the cause of the seaweed's browning. Fucoxanthin has much promise and prospective uses in improving human health [23]. With chlorophylls a and c as well as beta-carotene, fucoxanthin is an orange pigment. The anti-inflammatory, anti-cancer, anti-obesity, anti-diabetic, anti-angiogenic, anti-malarial, antioxidant, and protective actions on the liver, cerebrovascular system, bone, skin, and eyes are the bioactivity of fucoxanthin. For its capacity to burn fat, it has undergone extensive research. [24,25].

- **PHYCOERYTHRIN**

The family of light-collecting phycobiliproteins makes the red protein pigment known as phytoerythrin. Together with the chlorophyll pigments that are essential for the most crucial photosynthesis, it is also present in red algae and cryptophytes. The red pigment that gives phycoerythrin its red hue is generated by the protease phycoerythrobilin. Together with the chlorophyll pigments, which are important for photosynthesis, phycoerythrin is another pigment. It absorbs light energy, which is subsequently transported to the reaction center by a pair of chlorophylls, often the phycobiliproteins phycocyanin and allophycocyanin. The fluorescent dyes with the highest luminosities are R- and B-phycoerythrin [26,27]. A protein that captures red light that is present in cyanobacteria, red algae, and cryptomonads is referred to as phytoerythrin. Phycoerythrin is made up of () monomers, which are typically arranged into the trimer ()3 or the disc-shaped hexamer ()6 that serves as the functional component of antennal rods. The -chain of these common complexes is a third sort of component. Moreover, phycoerythrin's molecular weight ranges from 20 to 260 kDa. [28].

- **PHYCOCYANIN**

In blue-green algae, phycocyanin is present. The body's blue-green hue is also a result of phytobiliprotein. Moreover, phycocyanin's fluorescent qualities are helpful for immunoassay assays. A pigment-protein combination from the family of light-harvesting phycobiliproteins is called phytocyanin. It is a supplemental pigment for chlorophyll. The light blue pigment phycocyanin absorbs both orange and red light, particularly at the wavelength of 620 nm. Moreover, the light emitted by phycocyanin has a wavelength of 650 nm. With great efficiency and minimal toxicity, phycocyanin may be extracted from marine creatures [29]. The benefits of phycocyanin as a food include antioxidant, anti-inflammatory, anti-cancer, and immune-boosting properties. They have strong hues and are water-answerable. Marine species can be used to isolate phycocyanin with great efficacy and minimal toxicity. Phycocyanins are natural colours used in food, cosmetics, and immunological testing in addition to being food additives. The presence of alcohols, a low pH, a high ionic strength, a high temperature, and other conditions make it unstable to light [30].



CLASSIFICATION OF ALGAL PIGMENTS

EXTRACTION OF ALGAL PIGMENTS[31,32,33]

1.FREEZE THAWING:

The powdered dried macroalgae were individually combined with distilled water at a ratio of 1:25, refrigerated at -21 °C for two hours, and then defrosted at room temperature of °C. At 5000 rpm for 15 minutes, the extract was centrifuged. A phosphate buffer (0.1 M) was also used to carry the extract.

2.MECHANICAL SHAKING:

Separate mixtures of dried macroalgae powders and distilled water were shaken mechanically at 150 rpm for two hours at room temperature in a ratio of 1:25. 15 minutes were spent centrifuging the extract at 5000 rpm. Phosphate buffer (0.1 M) was used to perform extraction as well.

3. SOXHLET EXTRACTION:

The dried macroalgae powders were loaded into a separate thimble and treated for 5 cycles with three different solvents, namely acetone, methanol and chloroform, at their boiling points. The extracted solvents were separated using a rotary evaporator.

APPLICATIONS

1.FOOD INDUSTRY:

Phycocyanin dyes are generally non-toxic and non-carcinogenic.Food uses of phycocyanin include coloring of soured dairy products, ice cream, chewing gum, soft drinks, alcoholic beverages, desserts, sweet cakes, and milkshakes. It has several advantages such as cheaper production, higher yield, easier extraction, cheaper raw materials[34,35].

2.TEXTILE:

Algae contain color pigments that can be used by the textile industry to dye fabrics and also as food, as these pigments have been found to have various antimicrobial and antioxidant properties. Algal pigments could be effectively used as natural fabric dyes instead of synthetic dyes because extraction methods are economically feasible, environmentally friendly and do not cause health hazards. However, further workneeds to be done in areas such as antimicrobial properties of different algal pigments, colorcharacterization, color fastness and dyeing efficiency[36,37].

3. PHARMACEUTICALS:

More and more clinical studies on the health benefits of algae metabolites and pigments have alsomade them a safe and useful substitute for chemically synthesized drugs. The human bodytransforms beta-carotene into vitamin A through body tissues,unlike the liver, thus preventing the accumulation of toxins in the liver.Beta-carotene has antioxidant properties.Pigment and protein complexes derived from microalgae, such as phycobiliproteins, phycocyanin,phycobilins and phycoerythrins, offer anti-inflammatory, antioxidant, antiviral, hepato-,nephroprotective, and neuroprotective agents to the market[38,39]

4.COSMETICS

The excellent photophysical properties, rich nutritional value, antioxidant nature and antiagingcompounds in algae have led to its use in cosmetics and skin care products. Algal pigments are usedto add exotic colors to soaps. Algae(macroalgae) is a source of pigments for various hair color products due to itslong-lasting properties. microalgae can be incorporated into cosmetic and cosmetic products andcan help achieve benefits such as hair, nutritive,Skin soothing, anti-inflammatory, Antioxidant, skin-elasticity, collagen synthesis, anti-wrinkle, emollient, moisturizing, Skin softening, Tightening effect and stimulatesmetabolism, Skin-conditioning agent, de-pigmentation[40,41]

5.CANCER STUDIES

Carotenoids, chlorophylls and phycobiliproteins. Marine pigments, β-carotene, fucoxanthin,astaxanthin, violaxanthin, halosynthiaxanthin, lutein, zeaxanthin, canthaxanthin, peridinin,phycocyanin, and chlorophyll derivatives exert strong antiproliferative effects by inducing apoptosisand DNA activation of cancer cells in breast lines. Both phycocyanin andphycoerythrin fluoresce at a specific wavelength. The light produced by this fluorescence is so clear and reliable that phycobilins can be used as chemical. The pigments are chemically linked to antibodies, which are then placed in the cell solution[42,43].

CONCLUSION

Due to the significant characteristics, algal pigments possess various environmental and health concerns. The utilization of algae as a source of natural colours is a result of growing knowledge of the negative effects of synthetic dyes and societal trends towards using natural products, such as plant and microbe-based colours in various applications. Algal pigments are increasingly in demand as food additives, feed, nutrient supplements, and colours because they have a much higher bioactive potential than other biological pigments. Moreover, it has been well received for use in medicines, cosmeceuticals, and nutraceuticals. These pigments have a wider range of uses as anticancer and anti-inflammatory medicines because of their great antioxidative potential. Further research can be conducted on developing various products using algal pigments due to its bioactivities.

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