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Research Paper

Review of Pigments in Animals, Plants and Microbes

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Pigments are colorants that are frequently utilized in food [1], beauty products, and pharmaceutical industries [2],[3]. Pigment is a substance that, by wavelength-selective absorption, modifies the color of reflected or transmitted light. Pigments can be obtained synthetically and naturally[4]. While synthetic pigments are made chemically and frequently have preferable color consistency and qualities than natural pigments, natural pigments are taken from minerals, plants, or animals. Nowadays, natural pigments are one of the natural dyes that may substitute the place of synthetic dyes in a variety of applications, particularly in the food sector. Natural pigments can be derived from microorganisms including bacteria, fungus, and algae as well as from plants and animals [5], [6]. The chemical structure of the pigment and its reaction to light has an impact on its coloration. Our eyes perceive color because certain pigments absorb certain wavelengths of light while reflecting others. A color's longevity may vary or alter depending on its chemical structure and the environment in which it exists. For example, certain hues are more suited for specific applications since they don't fade as easily when exposed to heat, light, or chemicals [7]. Not every colorant is safe for use in all applications. Some may be poisonous if consumed, inhaled, or soaked up through the skin. Therefore, it's crucial to select them for particular applications..

Pigments can be divided into two categories according to their source : natural and synthetic. Synthetic pigments are made from a mixture of two or more ingredients or chemicals. In terms of efficiency and raw material costs, synthetic pigments are frequently economical when produced in large quantities. Natural pigments are made from natural ongredients, such as plants, animals and minerals. Plant-based pigments have been utilized as safe food coloring additives as they are produced by plants as secondary metabolites. According to Raspati D. Mulyaningsih[8], the color intensity of natural pigments is unstable. Due to production costs, restricted availability, and extraction procedures, some natural pigments are more expensive than synthetic pigments [1]..

Pigments are used in various industries including:
a. Textile Industry: In the textile industry pigments are used as coloring in fabrics [9].
b. Paper industry: In the paper industry serratia marcescens can also be used as a coloring agent for paper.
c. Food industry: in the food industry, dyes are used as food additives to color food to make it more attractive [1].
d. Cosmetic industry: as a natural colorant in soap formulations, cosmetics [10].

a). Pigments in animals

Animals utilize color to communicate with each other and to impact interactions with parasites, predators, and the surrounding environment [11]. Animal pigments serve a variety of purposes, such as modulation of other biological processes, communication, crypticism, and protection. Animal pigment synthesis frequently entails a sequence of biochemical events regulated by genetic and environmental variables. The distinct expression and distribution of pigments in different animal species are influenced by a mix of environmental and genetic factors, such as food, UV light exposure, and other elements. There are several types of pigments produced from plants and animals (table 1).

Table 1: Pigments produced from plants and animals

Source	Type of biopigment	Color	References
Shrimp shells	Carotenoids	Red	[12]
Squid ink	Melanin	Black	[13]
Turmeric	Curcuminoid	yellow	[14]
Skin of red dragon fruit	Anthocyanin	Red	[15]
Rosella flower petals	Anthocyanin	Red	[16]
Miana leaves	Anthocyanin	Ungu	[17]
Beet skin	Betacyanin	Red-purple	[18]
Cassava leaves	Clorofil	Green	[19]
Butterfly pea flower	Anthocyanin	Blue	[20]
Secang bark	Brazilin	Red	[21]

- **Melanin**: the most common pigment produced by animals and humans which is responsible for the various colors of skin, hair, eyes and animals also functions to protect tissue from damage by ultraviolet (UV) rays and provides pigment that functions as crypticism / camouflage .

- **Carotenoids**: red, orange, or yellow pigments found in the skin, feathers, or scales of birds and fish from their diet [22]. These pigments give fruit and vegetables function as antioxidants and protect plants from damage caused by UV radiation and oxidative stress . Beta-carotene serves as a precursor for vitamin A, which is critical for both plant and animal health [23].

- **Bilirubin and Hemoglobin**: These pigments give the skin and eyes a yellow color when metabolic disorders or disease occur because they are related to physiological functions such as oxygen transport. Bilirubin, which is produced from the breakdown of hemoglobin in the liver [24].

- **Chlorophyll** : Green pigment called chlorophyll is used in photosynthesis. Chlorophyll uses solar energy to convert carbon dioxide and water into glucose. The chloroplasts in plant cells are where this process takes place. Chrorophyll a and b are the two primary forms of chlorophyll .

- **Anthocyanin:** pigment that gives some flowers, fruits, and leaves their red, purple, or blue hues. Among many other things, anthocyanins play a part in drawing pollinators and shielding tissue from UV rays. Light intensity, temperature, and diet are examples of environmental elements that can affect the formation of anthocyanins.

- **Flavonoids** : Anthocyanins, flavonols, and other flavonoids are among the many different chemicals that make up the large class of pigments known as flavonoids. Plants use flavonoids for a variety of purposes, such as defense against UV rays, infections, and pests, as well as interactions with other living things like pollinators [25].

b). Pigments in plants

Plants use internal biological mechanisms to create pigments in their cells[26]. These pigments perform a multitude of tasks, such as attracting pollinating insects, protecting against damage or infections, and absorbing light for photosynthesis [27]. Plants produce pigments through intricate biochemical pathways that are regulated by several environmental conditions, including light, temperature, water, and nutrition, in addition to plant genetics. The production and accumulation of pigments in plant tissues depend on proper gene expression, and variations in the environment can affect the amount and distribution of pigments in plants [28].

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c). Pigments in microbes

Different hues can be produced by microbes through a variety of biochemical pathways, including bacteria, fungus, and microscopic algae. The many purposes of pigments made by microorganisms include interacting with their surroundings, competing with other species, and providing defense against environmental stress [29]. Microbial genetics frequently regulates the generation of pigment by bacteria. Pigment formation can occur as a reaction mechanism when specific genes are expressed in response to environmental stimuli such UV light exposure, nutritional concentration, or oxidative stress [30]. Pigment can be produced by a variety of microorganisms. There are several microbes that can produce pigment, including (table 2):

Table 2: Pigments from microbes

Microbes	Type of biopigment	Color	References
Xanthomonasoryzae	Xanthomonadin	Yellow	[31]
Streptomyces sp	Melanin	Brown, Black	[32]
Serratia mercescens	Prodigiosin	Red	[33]
Pseudomonas	pyocyanin	Blue green	[34]
Neurospora intermedia SSF	Carotenoid	Yellow orange-red	[35]

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