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FUNGAL PIGMENT

An unusual source of cosmetics

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Abstract : These days, natural pigments are frequently used as food additives to change the color or taste of food items. These pigments' various nutritional and functional qualities make them important food ingredients utilized in the food business. Any food's color is a crucial component since it influences how well-liked the goods are by consumers. Because natural pigments have significant safety margins, consumers' attention has recently switched towards using them as food colorants. Due to the negative consequences of artificial colors, the food industry prefers to employ natural hues in foods and beverages. These pigments include lutein, betacyanin, betalains-betaxanthin, zeaxanthin, β-carotene, flavonoids-anthocyanins, and chlorophylls-chlorophyllin's, among others. Depending on where the color comes from, there are several limitations when using natural pigments.

***IndexTerms* - :** color; natural pigments; fungal pigments; dyeing; textile fabrics, antimicrobial agents, antioxidant agents, cytotoxic agents and anticancer agents.

INTRODUCTION

All life on Earth has always been influenced by color in some manner. Due to the employment of color in many facets of human existence, including clothing, food, and furnishings, life has become really "colorful". The primary source of color, which is an essential component of all plants and organisms, is pigments. The food product's color is altered and intensified by the pigments during processing.

In addition to helping to identify the product, they also protect nutrients, improve the product's original color, maintain its sensory quality, and raise its acceptance. These can be found in fungus, bacteria, and other structural components of animals as well as in plants, fruits, vegetables, leaves, skin, and eyes. Plants are their primary source; for example, green plants contain green pigments, onions contain pink pigments, turmeric contains yellow pigments, and beetroot contains red pigments. Fruits and vegetables high in pigment typically make up a portion of our diet. Fruits also have trace amounts of pigments connected to other food elements like fats, proteins, and dietary fibers. There are four primary types of vegetable pigments: flavonoids, carotenoids, betalains, and chlorophyll. The natural pigments used in food products are displayed in Fig. 1. [1].

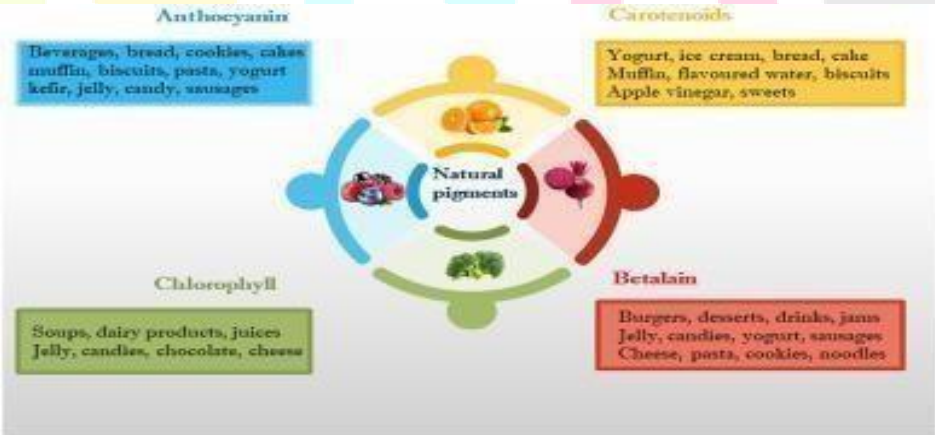

Fig: 1

People prefer natural meals from a nutritional stand point because they don't include artificial coloring or allergies. Foods, medications, clothing, and cosmetics all use pigments, which can be found in both natural and synthetic forms. They are used on processed goods including flavored milk drinks, sweets, gels, jellies, jams, and frozen meals like ice cream. For example, dietary supplements are colored using betalains. Because they dissolve in oils, carotenoids can be found in butter, oil, cheese, juices, baked goods, yogurt, and sweets. toothpaste, bed linens, and chewing gum all contain chlorophyll. [2]

A SOURCE OF PIGMENT IS FUNGI

New research into the sustainable sources of natural colorants is necessary due to rising demand, resource limitations, and a number of drawbacks associated with currently authorized natural pigments, including their seasonal availability limitations, instability against light, heat, and adverse pH, variability in pigment extraction, and low water solubility. Due to the chemicals they contain that have great light and chemical durability, a variety of colors, high output, and a sustainable supply, fungi have recently gained particular attention for the manufacture of natural pigments. [3].

Since the 19th century, the creation of pigments by fungal colonies has pique the curiosity of mycologists and can be thought of as a microbial reserve for the manufacture of Based on the presence of chemicals with high light and chemical stability, a range of hues, high output, and a sustainable supply, natural pigments are preferred. Since the 19th century, the creation of colors by fungal colonies has piqued the curiosity of mycologists and can be seen as a microbial reserve for the manufacture of food-grade colors. Melanin, anthraquinones, hydroxyanthraquinones, azaphilones, carotenoids, oxo polyene, quinones, and naphthoquinone are just a few of the many colors that fungi are known to make (Figure 1) Chuyen and Some of the colors and tints in Figure 1 created by several metabolite classes, and their fundamental chemical structures may be seen. The strain Penicillium oxalicum var. armeniaca CCM 8242, which was isolated from soil, has created Arpink red TM pigment (Natural red TM), the first red dye produced commercially by a fungus. [4]. Many of these pigments are biosynthesized derivatives of polyketides, which are abundantly generated in the majority of ascomycetous fungus. g Such examples of ascomycetes fungus include Neurospora spp. and Monascus spp., which point to an important field for future research. Terpenoids, polyphenols, and carotenoids are other groups of colored metabolites found in diverse filamentous fungus in addition to polyketide-based compounds. Table 1 lists some of the frequent pigments made by these species so that you may have a better idea of the range of color these molecules can generate. Flavins, which operate as enzyme cofactors, are among the natural pigments that are shown to have a variety of pharmacological properties and assist fungus in a variety of biological functions. They also protect against the damaging effect of photooxidation (carotenoids[4].

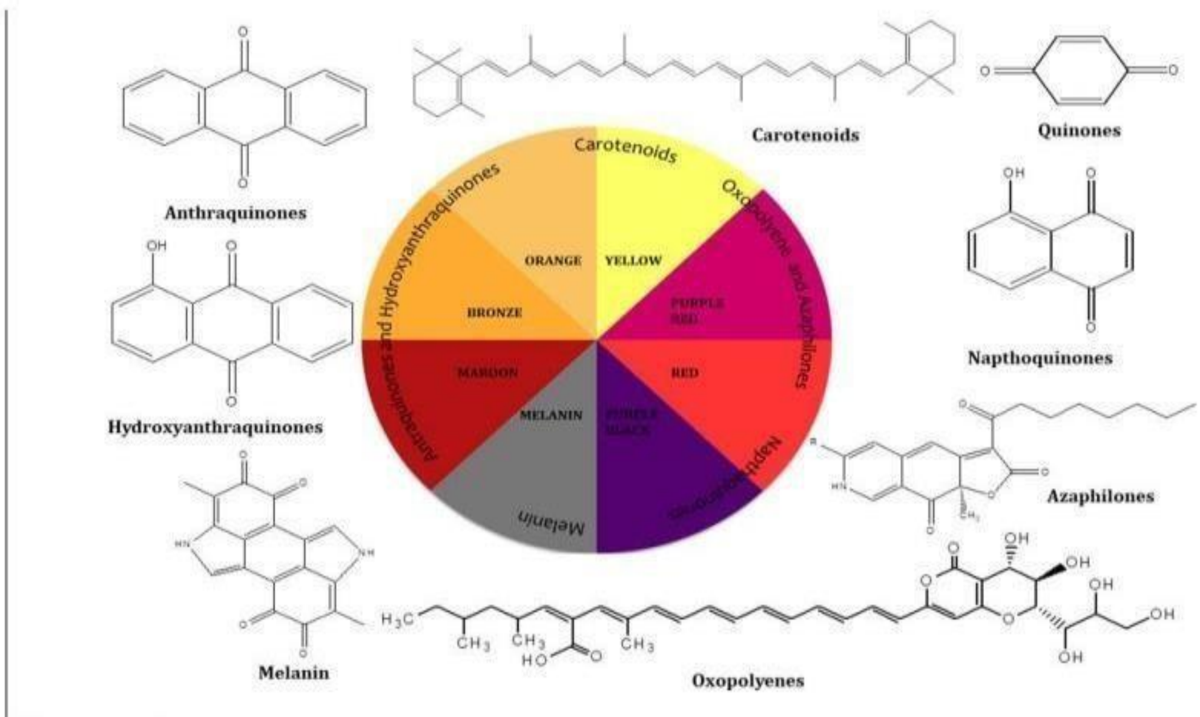

FIGURE 1 | Different hues of colors produced by different classes of compounds.

Fig:2

NATURAL AND SYNTHETIC SOURCE OF PIGMENT

(A) flavone, a yellow pigment produced by paints,
(B) carminic acid, a red pigment produced by scale insects,
(C) copper phthalocyanine-blue, a blue pigment of the synthetic phthalocyanine family,
(D) benzidine yellow, an azo pigment of the synthetic arylide family,
(E) PV19, a red pigment of the synthetic quinacridone family. Each molecule is colored to match its perceived color.[5]

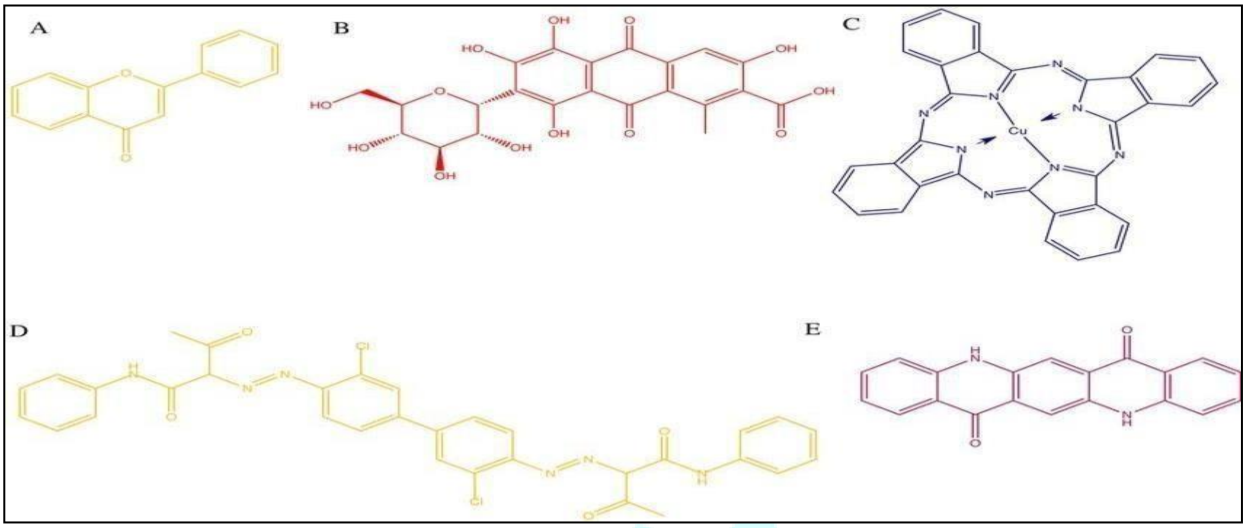

Fig:3

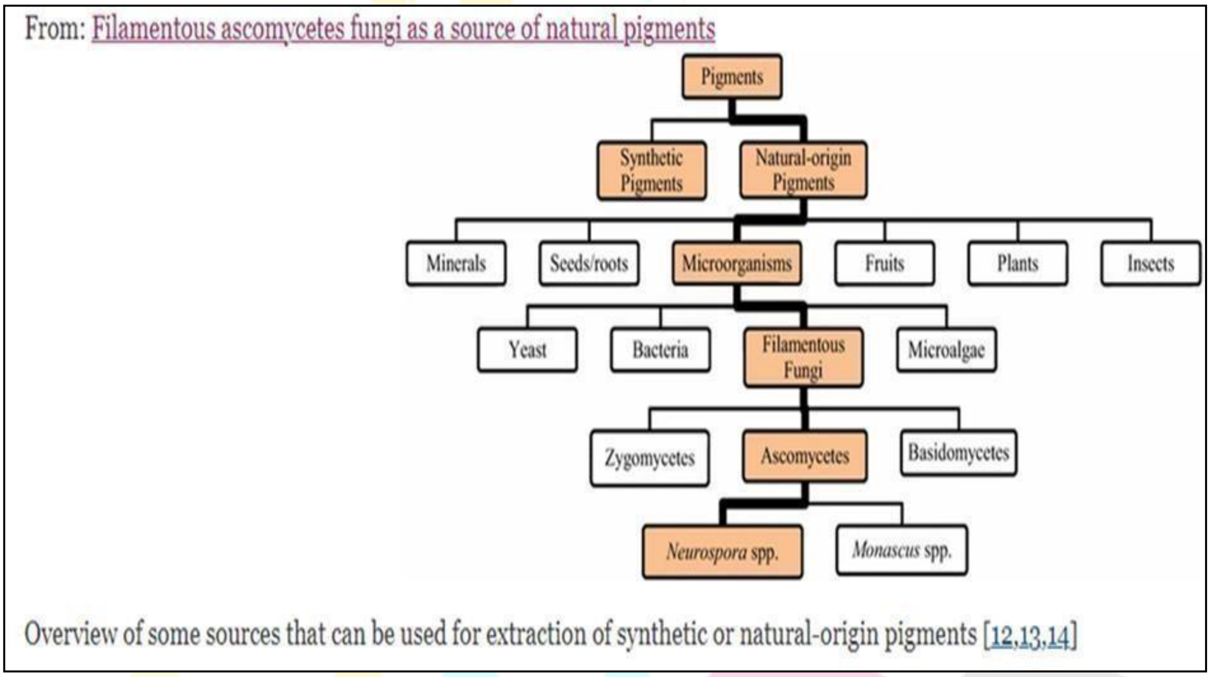

Fig:4

REQUIREMENT OF COSMETICS

There are many different kinds of cosmetics, and they may be divided into two groups. Goods that are used topically , such creams, lotions, and ointments, are referred to as "cosmeceuticals," whereas products with comparable alleged effects that are taken orally are referred to as "nutricosmetics." Cosmetics must meet a number of criteria, but the most crucial is that they be safe to use, have no negative side effects, and improve the skin. Natural ingredients are increasingly being used in cosmetics (such as Murad products). We go through a few of the qualities now employed in cosmetics below. In order to make the review succinct, we mostly focus on cosmeceuticals. The takeaway is that several fungi-derived compounds are utilized in cosmeceuticals or nutricosmetics, and that potential goods have not yet been put to use. [6].

SKINCARE PRODUCTS

The majority of skin care products are for makeup, but there are also skin whiteners, anti-aging, and anti-wrinkle products. Skin revitalizing and anti-aging. Anti-aging and revitalizing the skin go hand in hand, since good toned skin without wrinkles is necessary. There are various items available, and many of them contain either actual mushrooms, products made from mushrooms, or things that may be fermented using fungus. An alpha hydroxy acid called lactic acid is employed in cosmetic products. [7].

Dermatology to hydrate and smooth dry, flaky skin (examples: B Kamins Lactic 8 and Kinara Lactic Acid Hydrating Serum). It may occasionally be used as a chemical peel (e.g., Skin Cuticles Gel Peel GL Glycolic/LacticAcid Peel) in greater concentrations (over 12% medical grade), which removes the skin's outer layer. Lactic acid may be generated by Rhizopus strains, according to recent research. Ceramides are also employed in cosmetics as epidermal moisturizing agents, although they are pricey owing to their scarcity (Bliss The Youth As We Know It, Zirh Rejuvenate Anti-Aging Face Cream, Elizabeth Arden Ceramide Purifying Toner). Ceramides have been discovered in a variety of fungi, including Phellinus pini, Tuber, and they may be possible resources for cosmetics. Mold lipases may potentially be bio transformed for the creation of ceramides.[8].

A copolymer called chitin-glucan can be found in the cell walls of Aspergillus Niger is among the fungus that were present (Gautier et al. 2008). Chitin-glucan is an excellent moisturizer and can aid in combating some skin ageing symptoms and offers promise for use in anti-aging and skin moisturizing formulations. The chitin-glucan component of KitoZyme is derived from Aspergillus Niger's mycelium, which thrives in the waste materials left over from making food- and druggrade citric acid. The Kiosmetine-CG now uses a number of ingredients. Chitin glucan production in some mushroom species has also been demonstrated and therefore might be included into cosmetic compositions. [9].

Superoxide dismutase, which is generated by mushrooms, is utilized in cosmetic goods to lessen free radical damage to skin, such as to lessen fibrosis after radiation treatment for breast cancer. It is known that superoxide dismutase may reverse fibrosis, possibly by converting myofibroblasts back into fibroblasts. Several cosmetic products for the skin and hair now on the market (such as Dermalogica Intensive Moisture Balance and Pevonia Botanica Oxygenating Combination) include superoxide dismutase. Numerous fungus have been found to contain polysaccharides, particularly -(1-3)-D-glucan, which has anti-cancer qualities and is used in cosmetics. Betaglucans from medicinal mushrooms, such as lentinan and kestin (polysaccharide-K), have been used in Japan as chemotherapeutic adjuncts. A liquid-soluble combination of polysaccharides and proteins (1-6) Agaricus subrufescens' fruiting bodies (also known as Agaricus blazei) contained - D-glucan, which had immune-modulation action. [10]. Omega-3 fatty acids are thought to help lessen numerous inflammatory-related illnesses from which the body suffers, including skin rashes and redness. Omega-3 fatty acids are employed in the manufacture of the PGE3 prostaglandins which control the inflammatory response. Omega-6 fatty acids are used by the body to treat eczema and other disorders characterized by dry or damaged skin. Omega-9 fatty acids are abundant in cell membranes, particularly in the flexible skin tissue. is significant. Particularly abundant in skin cells and a highly effective medium for transporting nutrients over the skin barrier is oleic acid. Oleic acid-rich oils are often extremely absorbent, which makes them popular in the skin care sector. The intercellular matrix of the skin can benefit from fatty acids. Additionally, they have been demonstrated to prevent collagen deterioration and enhance cellular performance. [11].

Linoleic acid has been isolated and found to be the primary compound with anti-mutagenic activity in Agaricus subrufescens (also known as A. blazei), and it also occurs in Astraeus species, Cordyceps Pleurotus sajor-caj (Nieto and Carolina Che Species of Mortierella and Rhizopus may generate -linolenic acid. The organic pigments known as carotenes and xanthophylls, which both include oxygen, are classified as carotenoids. [12].

SKIN WHITENING

Uneven skin pigmentation can cause blotches, regions of brown to grey discoloration, or freckling that may need to be treated cosmetically. Problems with skin pigmentation are caused by excessive or insufficient melanin production. Tyrosinase stimulates the production of melanin by melanocyte cells, which gives skin, hair, and eye color. Tyrosinase inhibition is the primary method used in the majority of skin-whitening procedures, which is then followed by chemical peels and other exfoliants. Ellagic acid is a polyphenol anti-oxidant that has been shown to have anticancer and skin-whitening effects. Antioxidant, anti-inflammatory, anti-microbial, and radical scavenging properties of gallic acid are well established. [13].

Both may be made from plant tannins using Aspergillus Niger fermentation. Recent research has demonstrated that Rhizopus species may provide an advantageous alternative source for the production of lactic acid, which is used to whiten skin. Lactic and glycolic acids are also utilized for this purpose. Azelaic acid, which is typically used to treat acne and is generated from a yeast that naturally develops on skin, is also a component of skin whiteners. It is frequently found in various formulations that combine alpha hydroxy acids with other ingredients. the ellagic acid is present in Cellex-C Advanced Skin Hydration Complex and Shu Uemura White Recovery EX+ Brightening, and lactic acid in both. In addition to being a byproduct of the fermentation process used to make sake from malted rice, kojic acid has long been utilized as a skin lightener. [14].

Additionally, kojic acid possesses antifungal and antibacterial effects. Kojic Di palmitate is frequently favored since kojic acid is unstable and glows brown in light; this substance also has anti-oxidant qualities. Lightened, a skin-lightening product made by Pharma Clinic, contains kojic Di palmitate, a substance derived from Japanese mushrooms that is said to work on darker skin tones. Kojic Di palmitate from mushrooms is also included in Suisse Lab Whitening Cream and Der mage Brightening Cream. [15].

Tyrosinase inhibitors are useful ingredients in skin-lightening products and other cosmetics; at the moment, many of the facial mask products available on the market include Ganoderma extracts. Evaluation of the inhibitory effects of several mushroom extracts on tyrosinase activity. One of the examined mushrooms was with regard to considerable inhibition, Ganoderma lucidum as compared to tyrosinase activity (IC50 value 0.32 mg/ml) ones made from basidiomycetes other than your own. The discovery that Inhibition of tyrosinase activity is present in mushroom extracts. Will help us understand their "healing" process better. Characteristics in different traditional Chinese herbal skin care products. Different mushroom extracts are also believed to has skinwhitening abilities. This idea is founded on believing fungus may bleach wood and other materials is "simplistic thinking." oxidize melanin Sporotrichum pruinosum was determined to be the most promising of the very few fungi that decolorized synthetic melanin in tests of wild fungal isolates for melanocytic activity. To create, a submerged aerobic procedure was employed. This strain produces a skin depigmentation enzyme. a portion of a pure enzyme was created and evaluated for its ability to depigment human skin corneocytes and the whole epidermis III and V phototypes this research reveals how effective rather than enzymatic breakdown of cutaneous melanin. Its synthesis is inhibited. This opens the door to the possibility of employing melanocytic enzymes in skin lightening cosmetics. [16].

NUTRICOSMETICS

Several nutritional supplements are utilized, and while they are not exactly cosmetics, they are briefly described here. Grifols frondose fruit extract is used in Perricone MDs Maitake Mushroom Extract. (Fig. 8). This is said to have active glycoprotein. Can help with weight loss and cardiovascular health. Mushroom Wisdom Inc. also manufactures a variety of dietary supplements (for example, Griffon Maitake Caplet, Fig. 8). It's the same fungus. Super is manufactured by the same firm. Tremella Tablets for bone and skin health, as well as other benefits (fig.7). [17].

MUSHROOM COSMETIC PRODUCTS

Many well-known companies include mushroom extracts in their treatments, such as Origins Plantidote Mega-Mushroom Treatment (Fig. 1), Actifirm Antizyme Renovation Mushroom, Alqvinia Eternal Youth Cream (Fig. 2), and Menard Embellir. Hypsizygus ulmarium is used in Estee Laudar beginnings and Avena (Table 1). Several mushroom products or mushrooms have been utilized as cosmetic additives to date. Positively Ageless by Aveeno Johnson & Johnson goods are one example (Fig. 2). They employ a mushroom extract containing a mix of Ganoderma lucidum with Lentinula edodes. They assert that the cream "has been demonstrated to aid in the acceleration of you to restore surface cells, the skin's natural renewal mechanism is used. [18].

It decreases the visibility of fine lines and wrinkles." Products from the Nano Works Pureology range for skin and hair contain a combination of Ganoderma lucidum and Lentinula. According to Table 1, edodes and Mucor miehei antioxidants, nourish hair, and provide anti-aging qualities. The brand-new line "Mega-Mushroom" is one instance. Items, including a combination of three distinct Hypsizygus ulmarium, Cordyceps, and other mushroom extracts lucidum Ganoderma. The hypsizygus ulmarium is widely renowned for its numerous advantages. Consuming it may contains anti-cancer qualities and can lower cholesterol levels, high nutritional value and abundant vitamins, proteins, and other nutrients non-saturated fatty acids and -glucans. In Chinese medicine, it is said to strengthen and revitalize the skin. Enhancing resilience to ageing symptoms. The same claims are made for other mushrooms in the compound, such as Cordyceps, which is recognized for its stimulating characteristics, and the reishi mushroom. The well-known Japanese mushroom "Reishi" (Ganoderma lucidum) as a lifespan enhancer [19].

The Israeli business "Med Myko Ltd" makes use of the Bioactive compounds found in edible mushrooms have medical and commercial promise. Med Myko extract glucuronoxylomannan is an acid heteropolysaccharide derived from pure mycobacteria. Tremella cultures Tremella glucuronoxylomannan is a glucuronoxylomannan. When bonded to a surface, it creates a film and is pH independent skin or hair. All of these ingredients are included in cleaning and massage lotions. Anti-inflammatory and antioxidant properties are claimed for these medicines. Antiallergic characteristics, wound healing speed, and avoid senile degeneration. [20].

Examples of mushroom containing products

1. Aquamella
2. Plantidote- mega mushroom face serum
3. Vitamega
4. Eternal
5. Aveeno
6. Laprainie
7. Aqua circulation hydrating gel
8. Surkan grape seed lift eye mak
9. Sulwhasoo hydroaid
10. Yves saint Laurant temps majeur elixir de nui

Fig:5

Fig:6

Fig:7

Some Products Containing Mushrooms

Products Name	Product Function	Fungus/Extract Present
Surkran Grape Seed Life Eye Mask	Improves skin around eyes	Tremella polysaccharide
Beauty Dry Aqua Circulation Hydrating Gel	Moisturizing gel	Tremella polysaccharide
Sulwhasoo Hydroaid	Hydrating cream Promoting clear, Radiant skin	Schizophyllum commune
Alqvimia Eternal Youth Cream Facial Máxima Regeneración	Anti-aging and lifting	Schizophyllum commune
Tan Ryuk Sang Firming Cream	Makes Skin tight	Ganoderma lucidum, Pleurotus ostreatus
Aveeno Positively Ageless	Lifting and Firming	Lentinula edodes
Menard Embellir Refresh Massage	Skin anti-aging	Ganoderma lucidum
Nano Works Shineluxe	Anti-aging & anti fade	Ganoderma lucidum
Vitamega Facial Moisturizing Mask	Renews & revitalizes skin	Agaricus subrufescens
La Prairie Advanced marine Biology night Solution	Moisturizer which nourishes	Tremella fuciformis
Yves Saint Laurent Temps Majeur Elixir De Nuit Kose Sekkisei Cream	Moisturizer which nourishes	Cordyceps Sinensis

Fig:8

FACTORS AFFECTING PIGMENT PRODUCTION

Fungal pigments are polyketides, which are secondary metabolites. Although they are nonessential metabolites for growth and reproduction, the developmental stage of the fungus has a significant impact on the synthesis of these pigments, and the developmental phases are regulated by both extrinsic and internal factors. pH, substrate, oxygen, temperature, water activity, and light availability are all factors to consider. The composition of the fermentative production medium, aeration rate, agitation rate, nutritional limitation, and the status of carbon supply all impact the development of second-generation metabolites. The pH of the medium influences fungal growth and hence secondary metabolite synthesis. M. purpures generates at pH 5 Penicillium sclerotium generates orange pigment at the same pH as red pigment. [21].

Monascus colors range from red-yellow to orange, depending on the cultivation circumstances. Other growing conditions for Monascus sp. include aeration and a nitrogen supply. Extracellular water-soluble pigment synthesis. Temperature is another major aspect influencing pigment formation. The ideal Monascus sp. was discovered to have a temperature range of 28-30 °C and a pH range of 4.5–8.5. The highest pigment synthesis has been found at pH 4.5. The color yellow. Penicillium sp. was discovered to extracellular pigment is produced at pH 9.0 and 30 °C. Typically, in higher fungi, Incubation temperatures of 25 °C are preferable since they demand a longer time period for growth Mycelial expansion. Additionally, other supplies including carbon, nitrogen, oxygen, and phosphorus are crucial. Increased oxygen levels and decreased carbon dioxide levels lead to a reduction in the biomass ratio and, consequently, the formation of pigment. Even the amount of light has an impact on the formation of pigment. According to reports, growing Monascus species in complete darkness produces synthesis of red pigment is successful whereas pigment loss is caused by lighting and then hypothesized the fungus' photoreceptor response. include the lighting. The pigment output was influenced by red and blue light. [22].

Musaalbakri demonstrated that M. purpureus FTC 5391 could synthesize red pigment from several carbon sources, including glucose, potato starch, and rice starch. In addition, tryptophan or 6- furfuryl aminopurine can be used as nitrogen. Source aided in the formation of extracellular pigment. The Gibberlic acid, vitamin B2, and other amino acids are added (L-leucin and glycine) adding to the liquid media also increased pigment synthesis. Fusarium verticillioides pigment synthesis increased in proportion to the carbon supply, glucose, and yeast extract. In Fusarium moniliforme, KUMBF1201 outperformed various peptone and yeast extracts in terms of pigment synthesis. [23].

FUTURE PROSPECTIVES

As previously stated, the usage of natural colors as food colorants in the form of red rice, wine, and so on goes back to the Bronze Age. In the nineteenth century, chemically manufactured colors took the role of natural colors. However, with the allegations of the health risks caused by these chemically manufactured hues, as well as the many requirements. As a result, demand for natural hues has increased over the world. Consumer knowledge of nutrition and health is growing, which has resulted in pushed the food colorant business, and natural dye consumption has also increased. Ascomycetous, basidiomycetous, and lichen fungi are the most commonly known to create a variety of pigments. Ascomycetous has received the most attention since they are easy to cultivate in the laboratory and hence facilitate massive industrial production. There are several accounts of large-scale pigment synthesis from ascomycetous fungus in a bioreactor under regulated conditions conditions. Furthermore, the use of fungus does not make the producer seasonally reliant. Previously, natural food colorants were only used in semi-fermentative foods. Riboflavin manufacturing, a natural yellow food colorant, is carried out by Ashbya gossypi and Eremothecium ashbyii. However, it has some limits exist since it is light sensitive and easily fades away. The creation DSMTM's production of b-carotene from Blakeslea trispora in the Netherlands was a success. Breakthrough in the food industry. Previously, the only source of the carotenoid lycopene was the tomato, however EU legislation now recognises B. trispora as a viable lycopene source. [24].

With the creation of several. Many synthetic hues have been outlawed in favor of natural ones. import of red dyes from the Sudan series is prohibited because reports indicate that it has a cancercausing impact. Red in hue. It is expressly stated in the European Parliament that any food item possessing. Using synthetic colors (such as ponceau 4R and sunset yellow carnosine) properly safety warning. Anthraquinones are among the several Polyketide pigments that are available. Azaphilone structure, naphthoquinones, and hydroxyanthraquinones, each of which displays a variety of colors. Monascus sp. polyketide pigments have traditionally been employed in the production of red rice wine, red soybean cheese, and Anka in Southern China,Japan, and Southeast Asia. Monascus sp. generates a variety of pigments, including Anka Flavin and monascin, which provide yellow hue, as well as monascorubrin and monascorubrin. Monas columbamine and rubropunctamine produce orange color, whereas rubropunctatin produces purple-red hue. It also generates the mycotoxin citrinin. It is a hepato-nephrotoxic chemical, hence its use is restricted. Although there were no instances of mortality from consumption in the literature, Anka, red rice wine, red soybean cheese In addition to Monascus, Penicillium has also been documented for the manufacture and continued use of human-friendly pigment. [25].

It has been reported that a pink red, anthraquinone-based bio colorant produced from Penicillium oxalicum is safe to use. Other Penicillium species, such as Penicillium aculeatum and P. pinophilum, are also known to produce Monascus-like pigment azaphilone. These strains are safe for human usage and do not create any additional mycotoxins. Penicillium herquei and Cordyceps unilateralism, which have a structure with the red pigments shikonin and alkanin obtained from plants, provide hope for the future. More food colors made from plants are currently available on the market. But because to their seasonal unavailability and lower output per cycle, the tendency has shifted toward microorganisms. Exploration of fungal variety for bicolor synthesis and lower or no mycotoxin generation continues, with a focus on the creation of water-soluble pigments. We can argue that fungal pigments have promising potential commercial applications creation of different hues Natural colors derived from ascomycetous fungus can act as a long-lasting natural color Data available imply that filamentous fungi may be utilized as pigment manufacturing cell factories Despite the fact that some of the species produce mycotoxins, and research is ongoing to discover new fungal poisons. Cell factories that are both affordable and humane. [26].

CONCLUSION

The primary goal of the pigment business, particularly for food grade pigments, is to find a sustainable and prospective supply of colors that are generally safe for human health and the environment. The present societal preference for "natural" components and customer worry about negative consequences renewed concern about the effects of synthetic pigments on health and the environment the desire to employ natural coloring agents Progressive growth employing a variety of biotechnological technologies for the production of items that are nutritious, appealing, healthful, and have excellent sensory quality has been noticed in recent decades, which has accelerated this process more cost-effective and ideal for bulk applications. Despite the fact that nature is a great supply of safe colors, there are important restrictions including the scarcity of raw materials and variations in pigment profiles. Relating to colors derived from plant sources, explore color industry's interest in the possibilities of microbially produced colors sources, especially those related to fungi. In light of the benefits provided by fungal variety, fungi are viewed as cell factories for the synthesis of pigment where researchers may experiment with functionality. Numerous fungi species are known to synthesize and supply a vast variety of pigments, many of which are linked to complex biological processes and an incredible diversity of hues. Although many traditional techniques for producing pigments, such monascin (from a fungus), are already well-developed, a lot of research is being done on discovering fresh options, new methods, and sources for these pigments are produced biotechnologically in a yield that is economic. Have progressed. Consequently, further study is required to determine optimizing pigment characteristics like production and content using techniques for metabolic engineering, an optimal growth parameter, introduction of inexpensive organic materials for value-added production, diverse elicitors for pigment formation are present, stabilizing techniques are used to improve the application of pigment, and appropriate greener and more ecologically friendly extraction techniques on a broad scale.

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