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PIGMENT PRODUCING BACTERIA AND ITS APPLICATION IN VARIOUS FIELD

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ABSTRACT

This review is an overview to study about the pigments produced by bacteria. Pigments come in a wide variety of colours, textures & gradient. Non-toxic nature of pigments produced by numerous microorganisms make them environment-friendly for its use in dye, foodstuff, pharmacy, textiles, cosmetics and other industrial purposes. Natural pigments produced from biological origin have medicinal & industrial importance as they are used as an antioxidant, antimicrobial, additives, colour intensifiers, and anticancer as well as they are economically beneficial. This study focuses at reviewing pigment produced by bacteria and its application in various fields.

KEYWORDS: Bacterial pigments, Quinones, prodigiosin, *Serratia*, synthetic colour, carotenoids, dyeing.

INTRODUCTION

Many of the synthetic colours are widely used in textiles, dyeing, clothing, and fast-moving production systems, creating a wide range of costs. In order to reflect the performance of synthetic colour, there is a global interest in developing the benefit of synthetic materials from natural sources. The use of natural resources in clothing, dyeing, manufacturing and advanced production systems has grown over the years (Unagal et al., 2005). Natural resources can be found in both large services and small items (Mizukami et al., 1978) (Ryu et al., 1989). The authoritative natural ingredients available from the plant have many disadvantages such as poor resistance to light, heat or badness, inability to pay for water and lack of money (Raisainen et al., 2002). The natural elements of the origin of small particles

are of great interest due to the stability of the parts produced and the presence of technological performance (Kim et al., 1998).

Smaller organisms can grow gradually which may lead to higher yield and be able to produce all year round (Jiang et al., 2005). Microorganisms have been used in the production of molecules from many long times likely in antibiotics and enzymes also in vitamins and nutrients and in many more. Interest in food industry is growing as use of natural ingredients in making food products. Ingredients like colourants are considered natural which are extracted from biological sources like plants or microorganisms. There are some natural pigments giving or producing bacteria which can be used as antioxidants. Material made from these microbial pigments can be used in food industry, cosmetics industries for making beauty products as well as in textiles for dyeing clothes naturally (Yusof, 2006). Smaller plants produce a variety of the nutrients such as carotenoids, melanin, flavones, quinones, and other extracellular compounds that are financially, aggressive or indigo (Dufosse, 2006). The benefits of pigment producing bacteria include the rapid growth of the culture in the medium, independent from the climate and the colour of different materials. Hence the production of microbial pigment is one of the most emerging research fields to signify its strength in the different industries. (Table-1)

Table 1: Pigment producing bacteria & its appearance based on pigment colour (Kamla M et al., 2012).

Microorganisms (Bacteria)	Pigments/Molecule	Colour/Appearance
Agrobacterium aurantiacum	Astaxanthin	Pink-red
Achromobacter	Zeaxanthin	Creamy
Chromobacterium violaceum	Violacein	Purple
Pseudomonas aeruginosa	Pyocyanin	Blue-Green
Serratia marcescens	Prodigiosin	Red
Staphylococcus aureus	Staphyloxanthin, Zeaxanthin	Golden Yellow
Xanthomonas oryzae	Xanthomonadin	Yellow

Advantages of bacterial pigments

The advantages of using bacterial pigments is as follows

- Easy to process and long list of selection.
- Very high quality as well as effective in other sources also.

- Fermentation process can be carried out easily and this process is also more productive as it can be incorporated into the other chemical error.
- It is easy to control the genes.
- Easy and fast teaching as well as learning method allow for pursue bioreactor operation.
- Bacterial components are removed using easy liquid-liquid extraction method to reduce operation fetch.

Types of bacterial pigment

Carotenoids

Carotenoid pigments are soluble in lipids, carotenoids found in red, yellow-orange colours. Carotenoids belongs to the chemical category group i.e., isoprenoid polyenes by absorbing or screening UV radiation (Dieser M et al., 2010) (Frengova G et al., 2009). Carotenoid also provide protection to bacterial cells mostly found in marine water bacteria for example: *Halobacterium sp., Brevundimonas sp. strain SD212, Paracoccus species, Micrococcus sp. strainPAH83, Altererythrobacterishigakiensis,* and *Sphingo microbium astaxanthinifaciens (Adzzie-S. et al., 2018).* It is a naturally lipid-soluble pigments from cold storage. Staphyloxanthin, an orange membrane-bound carotenoid found in *Staphylococcus aureus* gives gold colour to cells and acts as a virulence factor for the bacteria itself (Song Y et al., 2009).

Prodigiosin

Prodigiosin was first extracted from *Serratia marcescens* (Boger DL et al., 1987). Prodigiosin is sensitive to light. In water, prodigiosin are non-soluble, but prodigiosin are soluble in methanol and acetonitrile as well as chloroform and in alcohol as well as it is also soluble in ether (de Araújo HW et al., 2010). Prodigiosin is found or produced in Gram negative (-) bacteria like *Pseudomonas magnesiorubra*, *Hahella chejuensis* as well as, *Alteromonas rubra, Vibrio gazogenes, Zooshikella rubidus,* and *Serratia rubidaea* (Darshan N et al., 2015)

Role of pigments in various fields

1. Food industry

The attractiveness of food with revolution as well as looks or arrival is a main goal in the food industry for the gain. In wide range, food manufacturers are started using natural food colours, as certain synthetic colour additives have shown health problems because of their use. Use of natural food colours is very important in food industry by considering the health of the consumers. This need can be completed only by researching more natural ways of

producing natural food colours, it is important to find the different natural sources for producing less harmful as well as no synthetic food colouring as it is important to know the strength of such natural food dyes. In food industry, there is a wide variety of synthetic colours that has been used at commercial scale for production but an important role as naturally occurring pigments by bacteria which have less health-related issues that acts as food colouring agent by bacterial dyes, even the production and distribution process of these bacterial dyes are simple. The production of natural food colours for the purpose of food industrial fermentation process has several advantages like low-cost production, simple extraction process, more quantity of yield through weight development, it takes very small as well as cheap amount of raw materials and there is no any seasonal variation that can be produced in any season. The advantage of these bacteria is that it can be genetically modified by adding genetic code to colorants; natural colours extracted from bacteria are considered to be healthy for humans as well as considered as safe to use as a natural food colouring agent and will not only protect human health but also this process helps to preserve biodiversity of the environment, chemicals which are thrown out in the environment while producing synthetic chemical dyes proves to be harmful & they are not tolerant to the environment.

Scientists carried out the research to know the difference between food grade colours & they reported that soil bacteria can produce a good amount of natural colour in many industries. China University have reported blue pigment. They reported that this pigment can be added into the diet (Tadashi K et al., 1990).

Bacterial dyes are also used to enhance the colour and the appearance of the fishes also affects the pink colour of domestic salmon. Some natural food colours can also be used in commercial industries that can be used as antioxidants. Based on the study conducted on the carotenoid extracts of *Meiothermus sp. strain RP*, *Meiothermus sp. strain TP* and *Thermus sp. strain YY*, it can be undoubtedly stated that the carotenoid extracts have high antioxidative capacity. Moreover, bacterial colourants or pigments in addition to being environment friendly, it can also meet the need for probiotic colours & natural colours (Chidambaram K et al., 2013).

2. Pharmaceutical industry

The immunosuppressive function of prodigiosin was first invented by the Nakamura and his colleagues in the year 1989. This study demonstrated the presence of prodigiosin and metacycloprodigiosin in *Serratia* culture broth and identified a selective inhibition of T-cell

polyclonal proliferation compared with B-cell (Chidambaram K., 2013). These materials have been known to have antibiotics as well as antimalarial result and immune function.

Bacterial pigments are effective in treating many different diseases, these bacterial pigments have ability to fight with disease like cancer because these pigments have antimicrobial properties, anticancer properties and immune-suppressive properties. One of the bacterial pigments, which is produced by the human body is melanin (Kamal Uddin et al., 2014). Melanin protects the human skin from harmful UV radiation and this pigment is also used as sun cream blocks (Anu Mishra et al., 2019). Currently research on anticancer drugs is focused on searching for newer and effective chemotherapeutic agents with lower non-toxic effects. Various research on bacterial pigments as anticancer agents against different types of cancer have showed the potential of bacterial pigments as a promising anticancer agent. (автор AS Azmana et al., 2018)

Flexirubin (yellowish-orange), carotenoids which found in pigment producing bacteria which are usually yellow-orange in colour and pyocyanin which is usually blue-green in colour acts as novel component in producing antimicrobial. In these various colourants the red pigment has the highest antibacterial activity. Compare to this orange, yellow and green pigments has lower antibacterial activity (Chidambaram K et al., 2020).

The pigment such as xanthophyll act as nutraceuticals. As it prevents cancers, heart attacks and strokes as well (E. E. van der Wall et al., 2012) & even has good potential in pharmaceuticals and feed industry. It is confirmed that pigment which extracted from prodigiosin is highly strong therapeutic and also has anticancer properties (Chidambaram K., 2020). The pigment prodigiosin is very effective as it possesses anti-bacterial, anti-fungal, anti-protozoal, cytotoxic, and anti-inflammatory properties. In the earlier research it is found that the pigment from *Hahella* has immune suppressant as well as antitumor properties (Chidambaram K., 2020).

The prodigiosin analogues & its derivatives has anticancer activity (Soumya R., 2013) but also in primary human cancer cells from patients with B-cell chronic lymphocytic leukemia (Semyon Risin, 1992); where prodigiosin has been found to be an effective component of the prevention and treatment of diabetes (Chidambaram K., 2013). Violacein has been reported to have antiprotozoan properties, anti-cancer, antiviral, antibacterial, and antioxidant activities. Mojib et al. described two-colour antimycobacterial activity, violacein from the

genus *Janthinobacterium* and flexirubin from the genus *Flavobacterium* may be important compounds in the chemical treatment of tuberculosis. These features provide a possible use of violacein for therapeutic purposes. Around 32 pigments from bacteria thus provide a huge range of active organisms and continue to provide promising ways to eradicate the major antimicrobial challenge.

3. Dyeing industry

The textile companies produce and uses around 1.3 million tons of dyes, pigments as well as precursors of dyes (Chidambaram K., et al., 2013). The value of which is about $ 23 billion, nearly all of which are mass produced locally. However, unnatural dyes have certain restriction, in particular, because their manufacturing process requires harmful chemicals, for the safety of workers (Chidambaram Kulandaisamy Venil et al., 2013). The manufacturers may produce toxic waste, used as a dye in the textile industry. Research results have shown that pigment can be used as a natural dye to transfer red colour to different levels of textile materials. Alihosseini et al., highlighted the red pigment prodigiosin from *Vibrio spp.*

Ahmad et al., 2012 extracted prodigiosin red pigment from Serratia marcescens and also he extracted violet pigment violacein from Chromobacterium violaceum, (Chidambaram Kulandaisamy Venil et al., 2013) and then that extracted dye onwards tested its dyeing effectiveness also tested different fabrics like 100% cotton, 100% silk, 100% rayon, silk satin and poly ester (Carlos J et al., 1980). After observing the results, it was suggested that prodigiosin could be used for making acrylic dye (Siyuan Wang et al., 2017) and also can use to produce strong violace in colours were observed in 100% rayon and silk satin. *Serratia sp.* gives red dye anthraquinone from Dermocybe sanguine, Roseomonas fauriae gives pink pigments and Fusarium oxysporum, Trichoderma sp. and Alternaria sp. are easy for the textile industry to dye all fibers as well as, wool, silk, cotton also, nylon and acrylic fibers.

Current Limitation and Future perspective

Bacterial colours are one of the most exciting areas for health science research to demonstrate its use in various industries, annual specificity of pathogens and technical imperfections focused on reversing researchers' effort to change the colour of synthetic dyes from genetically engineered bacteria. Studies should be particularly concerned with finding an easy way to harvest bacterial pigments in order to increase industrial applications. There is also a need to look at different performance parameters that can cause variability due to mutations

and to develop. Future research on various technologies that can reduce costs and increase production productivity on a large scale.

CONCLUSION

Surrounding climate on earth is rich in colour, our environment on earth are also rich in pigment producing microorganisms (mould and yeast as well as bacteria). Microbial pigments are used as food colouring, as well as used as flavour agents and mortal agents as also they are widely used in medicinal plants. Of all the secondary metabolites that have antibiotic activity, in the all living groups (T. Weber, et al., 2003).

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