ISSN PRINT 2319 1775 Online 2320 7876

Research paper UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

The Promising Role of Microbial Pigments in Therapeutic Interventions from Antimicrobial to Anticancer Applications

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Abstract:

The antibacterial, anticancer, cytotoxic, and exceptional antioxidant characteristics of the bacterial pigments demonstrate their therapeutic nature. Because of the significance of bacterial pigments, a thorough analysis of the literature about the medicinal and industrial applications of bacterial pigments was deemed necessary. UV-visible spectroscopy was used to characterize the pigment; the absorption spectra span from 220 to 250 nm. After FTIR examination, the spectrum for strain BJZ10 revealed functional groups associated with alcohols, esters, sulfate, alkanes, and alkyls. (Gram-positive) Bacillus cereus and (Gram-negative) Escherichia coli were used to assess the pigments' antibacterial action, and significant results were compared. This investigation uncovered the brown pigment, renowned for its possible antibacterial properties, produced by Streptomyces sp. strain BJZ10. We will talk about in this essay. Microbial Pigments' Potential Use in Therapeutic Interventions: From Antimicrobial to Anticancer Applications.

Keywords:

Microbial Pigments, Antimicrobial, Anticancer, Applications, Cytotoxic, Antioxidant, Bacterial Pigments, Spectroscopy, Bacillus Cereus, Streptomyces, Gram Positive, Gram-Negative, Carotenoids, Non-Toxic, Melanin

Introduction:

Currently endangering public health are two major global health challenges: antibiotic resistance and malignancy. Although major side effects are frequently associated with traditional medicines, conventional anticancer techniques like

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surgery, chemotherapy, and radiotherapy have been established. Effective antibacterial therapies are now seriously threatened by antibiotic resistance. There is a growing need for more effective methods of using antibacterial and anticancer drugs to reduce the risks. [1]

Bacterial pigments as antimicrobial agents:

A substance that either destroys microorganisms (microbicide) or inhibits their growth (bacteriostatic agent) is called an antibiotic. Based on the bacteria they primarily target, antimicrobial medications can be categorized. Antibiotics, for instance, are used against bacteria, whereas antifungals are used against fungus. They can also be categorized based on the roles they play. Antimicrobial prophylaxis refers to the use of antimicrobial medications to prevent infection, and antimicrobial chemotherapy refers to the treatment of infection with antimicrobial medications.

Antiseptics (applied to living tissue to help reduce infection during surgery), disinfectants (non-selective agents, such as bleach), and antibiotics (which destroy microorganisms within the body) are the main classes of antimicrobial agents. Disinfectants kill a wide range of microbes on non-living surfaces to prevent the spread of illness. Originally limited to formulations generated from living bacteria, the term "antibiotic" is increasingly used to refer to synthetic drugs such fluoroquinolones and sulfonamides. [2]

Although the term was once limited to antibacterials (and is frequently used as a synonym for them in medical literature and by medical practitioners), its meaning has expanded to encompass all antimicrobials. Bacteriostatic agents are agents that inhibit or stop the growth of bacteria, and bactericidal agents are those that kill bacteria. As a result, developments in antimicrobial technology have led to solutions that are capable of more than just stopping the growth of microorganisms. Instead, scientists have created some porous material that, upon touch, will kill microorganisms. Antimicrobial resistance may arise from the overuse or improper use of medicines.

Prior to 1900, infectious diseases were the primary global cause of death for people. However, behind non-communicable diseases, infectious diseases have emerged as the world's second leading cause of mortality and the third leading cause in wealthy nations. The current high demand for novel antibiotics is a result of the growing number of resistant microorganisms. [3]

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The amount of new pharmaceuticals coming onto the market has declined over the past 25 years, but the prevalence of germs becoming resistant has increased, making it more difficult to give treatments. Pigments are an excellent substitute for antibacterial agents, according to several studies being done to find new ones. Antimicrobial properties of bacterial pigments against both Gram-positive and Gram-negative bacteria have been documented.

- Antimicrobial activity of carotenoids
- Antimicrobial activity of prodigiosin
- Antimicrobial activity of melanin
- Antimicrobial activity of violacein
- Antimicrobial activity of pyocyanin [4]

Bacterial pigments as anticancer agents:

One of the main causes of illness and death in humans, cancer is a non-communicable disease. Numerous anticancer medications have been created to date and are undergoing clinical trials. However, the main obstacles to cancer treatment are their limitations, adverse effects, and resistance to the therapies and treatments. The goal of current anticancer medication research is to find more potent, novel chemotherapeutic medicines that have minimal or no side effects. Many studies on the use of bacterial pigments as anticancer medicines against various cancer types have demonstrated the pigments' potential as a potent anticancer agent.

- Anticancer activity of carotenoids
- Anticancer activity of prodigiosin
- Anticancer activity of melanin
- Anticancer activity of pyocyanin [5]

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Review of Literature:

Green technology favors using more natural and less hazardous materials in production. Due to their carcinogenic precursor product and the environmental impact of their industrial waste disposal, several synthetic dyes and colorants are banned from the market. Conversely, natural colorants, dyes, and pigments have a high market value due to their many benefits, including safety, as well as their potential biological activity, including antioxidant and anticancer properties. The need to find new sources of natural pigments and food colorants is increased by these considerations. Nowadays, bacterial pigments are produced commercially in a number of industries, including the food, textile, and cosmetics sectors (Dufossé 2006). [6]

Particularly significant in the therapy of many diseases are bacterial secondary metabolites and pigments, which also include anticancer, antibiotic, and immunosuppressive qualities. Numerous secondary metabolites, including phenols, quinols, flavonoids, polyketones, peptides, terpenoids, steroids, and alkaloids, have the potential to be medicinal agents. These substances exhibit outstanding antibacterial, inflammatory, immunosuppressive, antioxidant, and anticancer properties (Korkina 2007). [7]

Natural pigments are a valuable substitute for synthetic dyes in many industrial uses, such as the food, pharmaceutical, cosmetic, textile, and aquaculture sectors. Many natural pigments have antibacterial qualities in addition to being beneficial for coloring. The food, pharmaceutical, and textile industries are the main industries where bacterial pigments find wide applications. Pigments suitable for food use, include lycopene, β-carotene, riboflavin, and monascus The food sector uses red colors. Pigments like anthocyanin, vitexin, and prodigiosin are frequently utilized in pharmaceutical medicine to cure illnesses. The textile sector also uses a number of bacterial pigments, according to Bintimohd AS (2016). [8]

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Objectives:

- Applications of microbial pigments.
- Bacterial pigments as anticancer, antimicrobial agents.
- Role of Microbial Pigments in Therapeutic Interventions from Antimicrobial to Anticancer Applications.

Research Methodology:

The overall design of this study was exploratory. The research paper is an effort that is based on secondary data that was gathered from credible publications, the internet, articles, textbooks, and newspapers. The study's research design is primarily descriptive in nature.

Result and Discussion:

Different kinds of organisms, such as bacteria, fungus, viruses, etc., can cause infections and diseases in both humans and animals. An antimicrobial agent is a medication that prevents germs from being pathogenic. [9]

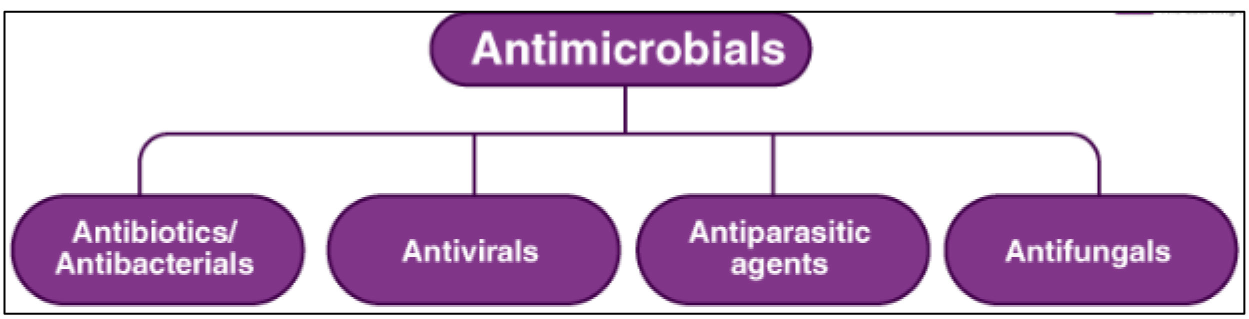

Figure 1: Antimicrobial Types [10]

Antimicrobial drugs are used to stop infections and illnesses brought on by pathogens. Antimicrobial medications come in a variety of forms. These are listed in the following order:

Antibacterial Drug: An antibacterial drug is one that works by preventing bacteria from acting in a harmful manner. Zithromax is one example.

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Antifungal Drug: An antifungal medication is one that stops the host from experiencing fungal activity. For instance, Miconazole

Antiviral Agent: Antiviral drugs are medications that block a virus's harmful activity. Tamiflu is one example.

Antiparasitic Drug: A drug that stops harmful parasites from growing. For instance, Anthelmintics.

Antimicrobial Activity

Using an agar well diffusion assay, the antibacterial activity of dried pigment extracted with methanol against pathogenic bacteria was assessed. Pigments were employed at three different concentrations: 50 mg/ml, 25 mg/ml, and 12.5 mg/ml. For the antimicrobial activity test, Gram-positive bacteria Bacillus cereus and Gram-negative bacteria Escherichia coli were utilized. [11]

After the chosen bacteria had grown for roughly 24 hours at 30°C on nutrient broth (NB) medium, 100 µl of the bacterial culture was put to the ready-made petri plates. Four wells, each with a diameter of 6 mm, were punctured on NB agar plates and contained varying quantities of dried methanol extract (12.5 mg/ml, 25 mg/ml, and 50 mg/ml). Each sample was put into the wells in an amount of 50 µl. In addition, the inoculation plates were given a 24-hour growth period, following which the clear zone of inhibition surrounding the inoculated well was identified. [12]

The extracted pigment's potential for growth suppression was to be tested through the proposed antibacterial analysis. The production of tissue-destructive exoenzymes is directly linked to the selection of the Gram-positive B. cereus from intestinal or non-intestinal sources. The strain is also known to produce toxins, including three different phospholipases, a toxin that induces emesis, four hemolysins, and proteases. However, the reason that Gram-negative Escherichia coli was chosen was due to their ability to induce human septic shock, severe food poisoning, meningitis, or urinary tract infections (see Figure 2). According to Table 1, the concentration of the pigment extracted was the main factor influencing the inhibition activity against different kinds of microorganisms. In particular, a concentration of 50 mg/ml produced the most promising 14 mm zone of inhibition

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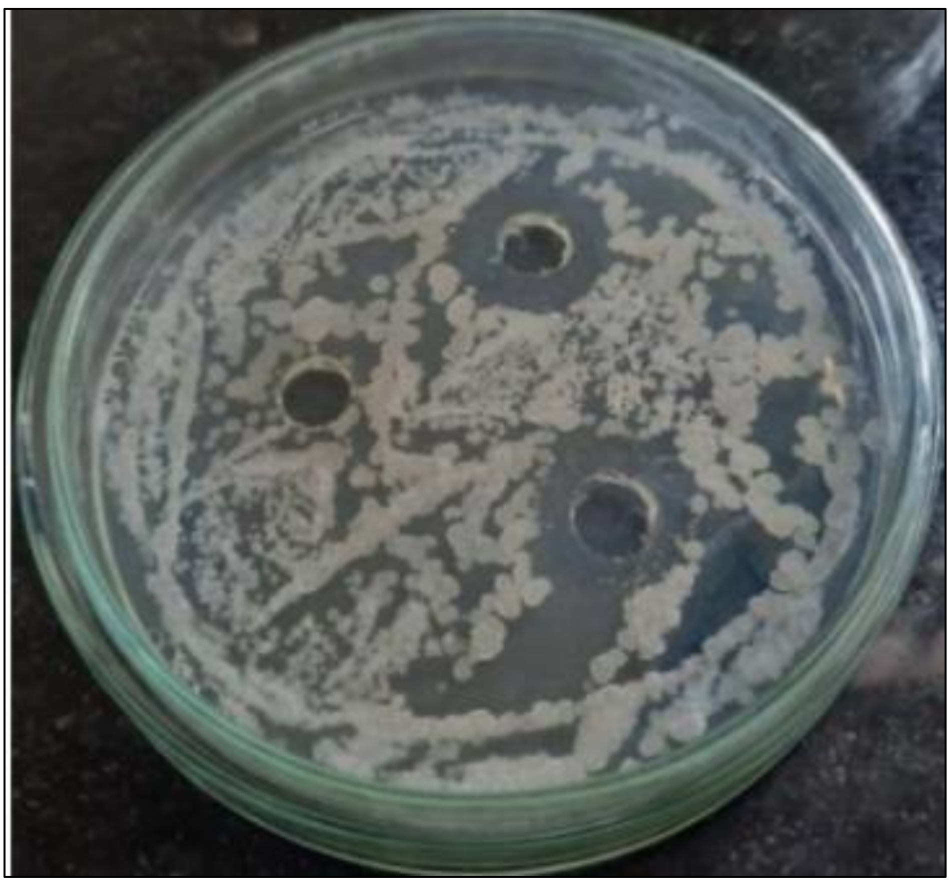
against the Bacillus cereus species, a facultative anaerobic bacterium that is Gram-positive, spore-forming, and anaerobic. where a maximum 10.2 mm zone of inhibition against the *Bacillus cereus* species was found in their findings.

However, when the extract was used at lower concentrations (12.5–25 mg/ml), the pigment recovered from the *Streptomyces* sp. showed little to no effect on the Gram-negative bacterium *Escherichia coli*; however, when the extract was used at higher concentrations (50 mg/ml and above), it was effective. Additionally, their strains did not exhibit any growth inhibition against the *E. coli* species. We may infer that strain BJZ10's brown pigment has been evaluated in relation to both Gram-positive and Gram-negative pathogenic bacteria. The observed data suggest that *Bacillus cereus* is more resistant to the tested colors than *Escherichia coli*. [13]

Figure 2: The antimicrobial effects of the extracted pigments on Gram-positive (a) and Gram-negative (b) bacteria.



(a) *Bacillus cereus*

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(b) *E. coli*

Table 1: Antagonistic effects of the extracted pigment against the *Bacillus cereus* and *E. coli. [14]*

Sl. no	Name of pathogen	Concentration of sample	Inhibition size of diameter in mm
1	*Bacillus cereus*	12.5 mg/ml	0.00 ± 0.02
		25 mg/ml	8.0 ± 0.3
		50 mg/ml	14±
2	*Escherichia coli*	12.5 mg/ml	0.00 ± 0.01
		25 mg/ml	0.00 ± 0.31
		50 mg/ml	4 ± 0.16

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Applications of microbial pigments:

The current research is concentrating more on versatile pigments made by microbes because of their widely documented uses in the food, textile, and biomedical industries. Many of these predictions are currently coming true since psychrophilic bacteria and their secondary metabolites are serving as invaluable and sustainable resources for the advancement of biotechnology. In contemporary study, pigments generated by these psychrophilic microbes are the main focus, among other important compounds. The isolated microorganisms from cryospheric conditions that produce possible industrial pigments (Fig. 3). The following are general uses for microbial pigments. [15]

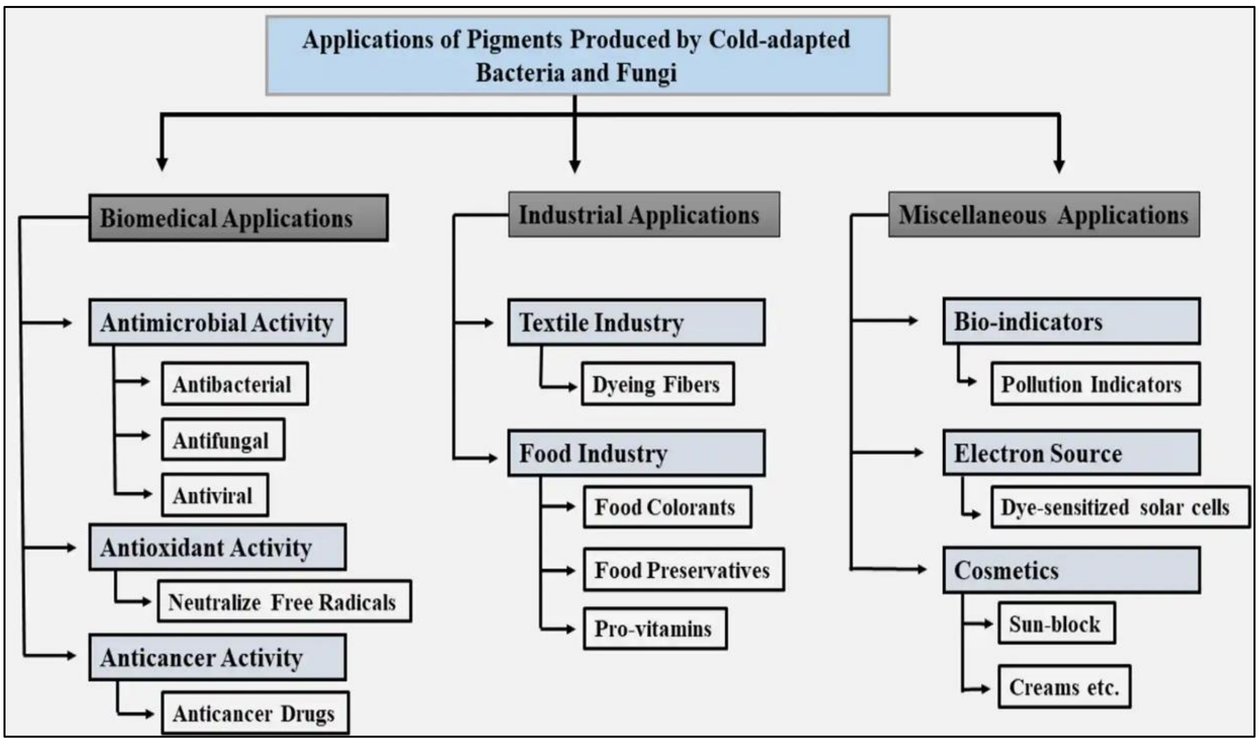

Figure 3: Schematic representation of the pigment's applications obtained from cold-adapted microbes

Biomedical applications

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- **Antimicrobial activities:**

After non-contagious diseases, infectious diseases rank third in industrialized nations and are the second leading cause of mortality worldwide. Over the past few decades, there has been a decline in the introduction of new drugs onto the market and an increase in germ resistance to antibiotics. The need for innovative antimicrobial drugs increased due to the growing trend of microbial antibiotic resistance. Several microbial pigments have been successfully tested for their antibacterial properties as alternatives to antibiotics.

Micrococcus luteus pigments that demonstrated the ability to suppress wound infections such Pseudomonas sp., Klebsiella sp., and Staphylococcus sp. The antimicrobial properties of carotenoids derived from Holomonas sp. were demonstrated against E. coli, antibiotic-resistant S. aureus, Klebsiella sp., and Pseudomonas aeruginosa, as well as ophthalmic S. aureus, Streptococcus pyogens, and E. coli. Additionally, the crude melanin derived from Streptomyces was found to be inhibiting E. coli. Streptomyces hygroscopicus pigment was efficient against infections such S. aureus that is resistant to vancomycin and methicillin, E. coli that produces β-lactamase, P. aeruginosa, and Klebsiella sp. Promising antibacterial activity were demonstrated by vitexin derived from C. violaceum and J. lividum. Significant antibiotic action against S. aureus and prevention of its biofilm formation were demonstrated by vitexin, which was isolated from C. violaceum ATCC 12472.

In a similar vein, Antarctic bacterial violacein shown efficacy against avirulent M. tuberculosis at lower concentrations. When violacein is used with antibiotics like cefadroxil and kanamycin, the inhibitory concentration of the medications against S. aureus is reduced. In addition, violacein isolated from J. lividum shown fungicidal action against Rosellinia necatrix, which causes white root rot. Prodigiosin from Vibrio ruber DSM 14,379 showed bacteriostatic action against Bacillus subtilis and E. coli. [16]

- **Anticancer activity**

Throughout human history, cancer has been one of the deadliest diseases. There are now a number of anticancer medications in the clinical trial stage of development. The main obstacles to treating cancer, however, are treatment resistance, side effects, and limitations on success.

Thus, there is a significant deal of interest in the hunt for new, potent anticancer drugs with minimal to no adverse effects. Studies using microbial pigments as

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anticancer drugs have shown encouraging outcomes in a number of different areas. Athrobacter sp. G20's unique red pigment was found to have anticancer properties when tested against the KYSE30 cell line, which is a model of oesophageal cancer. Strong cytotoxic action against HepG2 and cervical cancer cells (HeLa) was shown by a yellow pigment purportedly derived from Streptomyces griseoaurantiacus, which also reduced the amount of viable cells. A carotenoid isolated from Kocuria sp. QWT-12 has anticancer properties against lung and breast cancer cell lines.

Similarly, 53.52% of human liver cancer cell lines were destroyed by carotenoids derived from Haloferax volcanii. Significant cytotoxic effect was demonstrated by black melanin isolated from S. glaucescens against the HFB4 skin cancer cell line. When applied to the cervical cancer cell, dihydroxyphenylalanine melanin derived from Streptomyces sp. MVCS6 shown dose-response anticancer action. Prodigiosin recently demonstrated in vivo tumoricidal efficacy, promoted apoptosis in lung cancer cells, and decreased the intracellular signaling pathway during the cell cycle.

Fascinatingly, adding natural chemicals to chemotherapy medications both increases their effectiveness and lowers their toxicity. It has been observed that prodigiosin has an effective synergistic impact when paired with paclitaxel against MCF7 breast cancer cells and doxorubicin (Dox) against OSCC cell lines. Obtaining violacein from C. Furthermore, violacein promoted apoptosis in human breast cancer cells and colon cancer cells. Tumor cell inhibition is possible for a number of anthraquinone derivatives generated from fungi that are marine-sourced. The anticancer potential of anthraquinone derivatives derived from the fungus Alternaria sp. has been investigated in human breast cancer cell lines. The microbial pigment may be useful as chemotherapeutic agents in the treatment of cancer, according to the studies mentioned above. [17]

Conclusion:

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Microbes that have already adapted to human interaction without posing a threat to human health are among the most diverse species found in nature and are the source of microbial colors. Their bioactive qualities (antioxidant, antibacterial, and anti-inflammatory, to name a few) can even be used as colorants and additives to enhance compositions. For their production, application, and commercialization, further investments in the sector, laws, and regulations are required.

References:

1. Cheng, S.; Pei, Y.; Zeng, Y. Cosmetic Ingredient: Metabolism and Mechanism. *Highlights Sci. Eng. Technol.* **2022**, *6*, 74–82.
2. Ding, J.; Wu, B.; Chen, L. Application of Marine Microbial Natural Products in Cosmetics. *Front. Microbiol.* **2022**, *13*, 892505.
3. Celedón, R.; Díaz, L. Natural Pigments of Bacterial Origin and Their Possible Biomedical Applications. *Microorganisms* **2021**, *9*, 739.
4. Ramesh, C.H.; Vinithkumar, N.V.; Kirubagaran, R.; Venil, C.K.; Dufossé, L. Multifaceted applications of microbial pigments: Current knowledge, challenges and future directions for public health implications. *Microorganisms* **2019**, *7*, 186.
5. Sreenivasa N, Shashiraj KN, Bidhayak C, Meghashyama PB, Pallavi SS, Dattatraya A, Halaswamy H, Muthuraj R, Dhanyakumara SB, Anusha RP. Antimicrobial and enzymatic potential of *Streptomyces* sp. KAS-1 isolated from the microbiologically unexplored estuary of Kali River ecosystem. Int J Res Pharm Sci. 2020;11(2):1655–66.
6. Dufossé L. Microbial production of food grade pigments. Food Technology and Biotechnology. 2006;44(3):313–323.
7. Korkina L. Phenylpropanoids as naturally occurring antioxidants: from plant defense to human health. Cell Mol Biol. 2007;53(1):15–25.
8. Bintimohd AS (2016) Production of natural pigment with antimicrobial activity from a marine bacterium, pseudoalteromonas rubra. Thesis for the degree of Doctor of Philosophy.
9. Kulkarni A, Desai SV, Shet AR. Isolation and characterization of pigment producing actinomycetes from different sources. Res J Pharm Biol Chem Sci. 2017;8(3):101–9.

ISSN PRINT 2319 1775 Online 2320 7876
 UGC CARE Listed (Group -I) Journal Volume 11, Iss 12, 2022

10. Zhang D, Lu Y, Chen H, Wu C, Zhang H, Chen L, Chen X. Antifungal peptides produced by actinomycetes and their biological activities against plant diseases. J Antibiot. 2020; 73:265–82.
11. Berezin V, Abdukhakimova D, Trenozhnikova L, Bogoyavlenskiy A, Aizhan Turmagambetova A, Issanov A, Azizan A. Antiviral activities of extremophilic actinomycetes extracts from Kazakhstan's unique ecosystems against influenza viruses and paramyxoviruses. Virol J. 2019; 16:150.
12. Tkaczyk, A.; Mitrowska, K.; Posyniak, A. Synthetic organic dyes as contaminants of the aquatic environment and their implications for ecosystems: A review. *Sci. Total. Environ.* **2020**, *717*, 137222.
13. Usman, H.M.; Abdulkadir, N.; Gani, M.; Maiturare, H.M. Bacterial pigments and its significance. *MOJ Bioequiv Availab.* **2017**, *4*, 285–288.
14. Usmani, Z.; Sharma, M.; Sudheer, S.; Gupta, V.K.; Bhat, R. Engineered Microbes for Pigment Production Using Waste Biomass. *Curr. Genom.* **2020**, *21*, 80–95.
15. Pope CN, Schlenk D, Baud FJ. History and basic concepts of toxicology. In: An Introduction to Interdisciplinary Toxicology. Elsevier; 2020. p. 3-15. doi: 10.1016/B978-0-12-813602-7.00001-6.
16. Aslam, B., Basit, M., Nisar, M. A., Khurshid, M., and Rasool, M. H. (2017). Proteomics: technologies and their applications. J. Chromatogr. Sci. 55, 182–196. doi: 10.1093/chromsci/bmw167
17. Agboyibor C, Kong WB, Chen D, Zhang AM, Niu SQ (2018) Monascus pigments production, composition, bioactivity and its application: a review. Biocatal Agric Biotechnol 16:433–447