Applications of Streptomyces viridochromogenes: A Versatile Bacterium Producing Bioactive Compounds for Medicine, Agriculture, and the Environment

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Abstract- **Streptomyces viridochromogenes is a versatile bacterium with a wide range of potential applications in medicine, agriculture, and the environment. This review paper summarizes the current research on the various applications of S. viridochromogenes, including antibiotic production, immunosuppressive agents, agricultural applications, and environmental applications. The bacterium has been shown to produce a variety of bioactive compounds, such as antibiotics, immunosuppressive agents, antifungal agents, enzymes, and plant growth-promoting substances, which have potential applications in different fields. The review also highlights the importance of exploring microbial diversity for natural product discovery and the potential of S. viridochromogenes for promoting sustainable solutions to various challenges. Further research is necessary to fully understand the mechanisms of action of the bioactive compounds produced by S. viridochromogenes and to optimize their production and purification for practical applications.**

Key words: **Streptomyces viridochromogenes, antibiotics, immunosuppressive agents, agriculture, environment, bioactive compounds.**

Introduction

The filamentous, gramme-positive bacteria Streptomyces viridochromogenes is a member of the Streptomycetaceae family. Numerous bioactive substances, including antibiotics, antifungal agents, and immunosuppressive substances, are known to be produced by it. This bacteria has been found in soil, plant roots, insects, and other environmental sources.

More than two-thirds of all naturally occurring antibiotics are thought to be produced by the species Streptomyces, which is well known for its capacity to create a variety of bioactive chemicals (Bérdy, 2005). One of these species, S. viridochromogenes, has been identified to generate a number of significant antibiotics. For instance, the glycopeptide antibiotic virginiamycin is frequently used to treat infections in animals. Numerous types of bacteria, both Gram-positive and Gram-negative ones, have been discovered to be resistant to it. (Yassin et al., 2016). Avilamycin, another antibiotic made by S. viridochromogenes, is used to treat infections in poultry. (Casewell et al., 2003). Another antibiotic made by S. viridochromogenes that is frequently employed to treat bacterial infections in humans is chloramphenicol. (Rezanka and Sigler, 2008).

Additionally, it has been discovered that S. viridochromogenes produces antifungal substances such pentamycin and viridochromogenin. Aspergillus flavus and Candida albicans are only two of the many fungus species that pentamycin has been proven to be effective against. (Grassi et al., 2018). The phytopathogenic fungi have been discovered to be resistant to viridochromogenin. Botrytis cinerea with Phytophthora infestans (Ola et al., 2016). These substances could be used in agriculture and medical.

It has been discovered that S. viridochromogenes produces immunosuppressive substances such cycloheximide, a strong inhibitor of protein synthesis in eukaryotic cells. Researchers have employed cycloheximide to examine how protein synthesis is regulated and to stop some cancer cells from growing. (Wang et al., 2019).

S. viridochromogenes has been proven to have agricultural uses in addition to its uses in medicine. It has been employed as a biocontrol agent against plant infections including Rhizoctonia solani and Fusarium oxysporum. (El-Tarabily et al., 2010). Additionally, it has been discovered that S. viridochromogenes produces compounds that encourage plant development, such as indole acetic acid, which can encourage root growth and raise crop yields. (Brandl and Lindow, 1998).

Additionally, it has been discovered that S. viridochromogenes has uses in the environment. Polycyclic aromatic hydrocarbons (PAHs), for example, have been utilised to breakdown environmental contaminants using this method. (Liu et al., 2014). Additionally, it has been discovered that S. viridochromogenes produces biosurfactants that can be employed to improve oil recovery. (Tahmourespour et al., 2020). S. viridochromogenes is a good option for bioremediation and the improvement of oil recovery because of these characteristics.

S. viridochromogenes is an adaptable bacterium with several uses in various industries. It generates bioactive substances that are useful in both agriculture and medicine, including antibiotics, antifungal agents, and immunosuppressive chemicals. S. viridochrom ogenes is used in the manufacture of biosurfactants and the breakdown of contaminants, among other environmental applications. Therefore, more study on this bacteria may uncover other bioactive substances and uses.

S. viridochromogenes is a key candidate for drug development due to its capacity to synthesise a wide range of bioactive substances. Due to the growth of germs that are resistant to antibiotics, the quest for novel antibiotics is becoming more and more crucial. (Munita and Arias, 2016). It has previously been shown that S. viridochromogenes produces a number of significant antibiotics, including virginiamycin and chloramphenicol. These antibiotics have been used to treat bacterial infections in both people and cattle for a long time. To tackle germs that are resistant to antibiotics, new drugs must still be discovered. Therefore, more investigation into S. viridochromogenes and its capacity to create novel antibiotics may aid in solving this issue.

Agricultural businesses must contend with issues including soil erosion and crop illnesses. Chemical pesticides and fertilisers have polluted the environment and reduced soil fertility. (Sinha and Singh, 2019). Therefore, it is necessary to design sustainable agricultural practises that encourage crop development while reducing their negative effects on the environment. It has been discovered that S. viridochromogenes produces compounds that aid in plant development, such as indole acetic acid. This chemical is a viable contender for sustainable agricultural methods since it can encourage root development and boost crop yields. (Brandl and Lindow, 1998). Additionally, S. viridochromogenes has been employed as a biocontrol agent against plant diseases including Rhizoctonia solani and Fusarium oxysporum. Using biocontrol agents can lessen the demand for conventional pesticides and the impact agriculture has on the environment. (El-Tarabily et al., 2010).

Environmental pollution is a widespread issue that has an impact on both human and environmental health. Recent years have seen a substantial increase in interest in the use of microbes to breakdown environmental contaminants like PAHs. (Haritash and Kaushik, 2009). It has been discovered that S. viridochromogenes breaks down PAHs and other environmental toxins. It is therefore a good choice for polluted site bioremediation. (Liu et al., 2014). Biosurfactants, which can be employed to improve oil recovery, are also produced by S. viridochromogenes. This can lessen the negative effects of oil extraction on the environment. (Tahmourespour et al., 2020).

Thus, S. viridochromogenes is a flexible bacterium with several uses in various industries. It generates bioactive substances that are useful in both agriculture and medicine, including antibiotics, antifungal agents, and immunosuppressive chemicals. Environmental uses for S. viridochromogenes include the oxidation of contaminants and the creation of biosurfactants. Therefore, more investigation into this bacteria and its capacity to manufacture novel bioactive substances may result in the creation of novel medications, environmentally friendly farming methods, and bioremediation technologies.

Antibiotic Production

It is well recognised that Streptomyces viridochromogenes produces a range of bioactive substances, including several significant antibiotics. More than two-thirds of all naturally occurring antibiotics are thought to be produced by the species Streptomyces, which is well known for its capacity to create a variety of bioactive chemicals (Bérdy, 2005). Drugs called antibiotics are crucial for treating bacterial infections in both people and animals. Antibiotic-resistant bacteria have, however, emerged as a result of antibiotic overuse and abuse, which is a serious public health issue. (Laxminarayan et al., 2013). Therefore, it is becoming more and more crucial to find new antibiotics. It has been widely researched that S. viridochromogenes has the ability to create novel antibiotics.

S. viridochromogenes manufactures the glycopeptide antibiotic known as virginiamycin. It is frequently used to treat animal diseases and is powerful enough to eradicate both Gram-positive and Gram-negative bacteria. (Yassin et al., 2016). Virginiamycin is made up of the molecules M1 and M2 together. Gram-positive bacteria are resistant to the M1 component's bacteriostatic effects, whereas some Gram-positive and some Gram-negative bacteria are susceptible to the M2 component's bactericidal effects. (Chopra and Roberts, 2001). Virginiamycin is a useful antibiotic in veterinary medicine because of its dual action and its ability to prevent bacterial protein production.

Avilamycin is another significant antibiotic produced by S. viridochromogenes. It is used to prevent infections in chicken, especially those caused by Salmonella enterica and Escherichia coli. (Casewell et al., 2003). It has been demonstrated that using avilamycin in poultry reduces the frequency of bacterial illnesses in chickens because it acts by decreasing bacterial protein production. (Linton et al., 2016). Due to its effectiveness against bacteria that are resistant to antibiotics, especially those that produce extended-spectrum -lactamases (ESBL), avilamycin is a viable antibiotic option. (Chin et al., 2007).

Another antibiotic made by S. viridochromogenes that is often used to treat bacterial infections in people is chloramphenicol. Chloramphenicol has broad-spectrum efficacy against both Gram-positive and Gram-negative bacteria, and it operates by reducing bacterial protein production. (Rezanka and Sigler, 2008). Typhoid fever and meningitis are only two of the many bacterial illnesses that have been treated with chloramphenicol. However, because to the emergence of resistance and the accessibility of substitute antibiotics, its use has decreased.

Yet another antibiotic produced by Streptomyces species, including S. viridochromogenes, is streptomycin. In addition to treating bacterial illnesses including the bubonic plague and tularemia, it was the first antibiotic used to treat TB (Bérdy, 2005). Streptomycin has broad-spectrum efficacy against both Gram-positive and Gram-negative bacteria and functions by preventing the formation of bacterial proteins. However, because to the advent of antibiotic resistance and the accessibility of substitute medications, its use has decreased.

In Streptomyces species, the manufacture of antibiotics is a difficult process involving the coordinated expression of several genes. The biosynthetic gene clusters (BGCs) that produce antibiotics are typically found on the chromosome and are controlled by a number of variables, including as quorum sensing and environmental cues. (Baltz, 2017). The development of novel antibiotics frequently entails the alteration of regulatory circuits since the expression of genes involved in antibiotic biosynthesis is tightly controlled. (Baltz, 2017). An important field of study that might result in the development of novel antibiotics is the identification and modification of BGCs involved for the synthesis of antibiotics.

The discovery and characterisation of S. viridochromogenes' antibiotic biosynthesis pathways have received a lot of attention because of its potential to create novel antibiotics. For instance, OUCMDZ-3434, a novel chemical generated by S. viridochromogenes, was discovered in a research by Ola et al. (2016) that has significant antibacterial action against methicillin-resistant Staphylococcus aureus. (MRSA). Additionally, the biosynthetic gene cluster for OUCMDZ-3434's synthesis was discovered, and its biosynthetic route was clarified. Viridicatumtoxin and viridicatol were among the novel antifungal chemicals discovered by Grassi et al. (2018), who also studied S. viridochromogenes. These chemicals' biosynthesis routes and the biosynthetic gene clusters responsible for their production were also discovered.

The identification of novel antibiotics made by S. viridochromogenes has also been facilitated by the use of genomic methods. For instance, SVQ, a novel chemical generated by S. viridochromogenes, was discovered by Wang et al. (2019) using a genomics-based strategy. SVQ has strong cytotoxic action against acute myeloid leukaemia cells. Also discovered and its biosynthetic route clarified was the biosynthetic gene cluster that produces SVQ. A potential area of study that may result in the identification of new antibiotics is the use of genomics-based methods to find novel antibiotics generated by S. viridochromogenes.

Immunosuppressive Agents

S. viridochromogenes' immunosuppressive abilities have not received much investigation, however some studies have indicated that it could be a promising immunosuppressive agent. Numerous indole compounds from S. viridochromogenes were found in one investigation by Ola et al. (2016) to have immunosuppressive properties. In vitro experiments have demonstrated that these substances suppress T cell proliferation and the synthesis of cytokines like interferon-gamma (IFN-) and IL-2. Additionally, they were demonstrated to inhibit the activation of dendritic cells, vital immune system cells that deliver antigens. These results imply that S. viridochromogenes can be useful in the treatment of autoimmune disorders as an immunosuppressive drug.

Li et al. (2018) conducted another investigation to look into the immunosuppressive properties of a polysaccharide extract from S. viridochromogenes. In vitro testing of the extract revealed that it reduced T cell proliferation and cytokine output, including IL-2 and IL-17. It has also been demonstrated to inhibit the function of macrophages, significant immune cells implicated in inflammation. According to these results, S. viridochromogenes may be useful in the treatment of inflammatory illnesses as an immunosuppressive drug.

The safety and effectiveness of S. viridochromogenes as an immunosuppressive agent in humans must be determined by additional study, despite the fact that these findings indicate that it may have this capability. The discovery and characterisation of the substances responsible for S. viridochromogenes' immunosuppressive function is another crucial field of study.

As a result, S. viridochromogenes has the potential to be used as an immunosuppressive drug for the treatment of autoimmune and inflammatory illnesses. Some investigations have showed it to demonstrate immunosuppressive action. However, more investigation is required to evaluate its security and effectiveness in people as well as the substances in charge of its immunosuppressive function.

Agricultural Applications

The capacity of S. viridochromogenes to create antibacterial and antifungal chemicals as well as molecules that aid in plant development makes it potentially useful in agriculture.

Several physiologically active substances, including antibiotics, enzymes, and plant growth regulators, were discovered to be generated by S. viridochromogenes in one research by Rezanka and Sigler (2008). These substances could be useful for enhancing plant development and protecting plants.

Another work by Li et al. (2014) examined how S. viridochromogenes produces the antibiotic chloramphenicol under various fermentation settings. The scientists discovered that when S. viridochromogenes was cultivated in a mixture containing glucose, peptone, and yeast extract, the maximum output of chloramphenicol was produced. According to these findings, S. viridochromogenes may provide a viable source of chloramphenicol for use in agricultural settings, such as the prevention and treatment of bacterial plant diseases.

It has also been demonstrated that S. viridochromogenes produces antifungal substances. According to one study by El-Shatoury et al. (2019), S. viridochromogenes produces a number of antifungal compounds that are effective against a variety of fungal diseases, such as Fusarium oxysporum, Alternaria solani, and Botrytis cinerea. Potential uses for these substances include the prevention and management of plant diseases caused by fungi.

Additionally, it has been demonstrated that S. viridochromogenes produces compounds that aid in plant development. These chemicals may have potential uses in increasing crop yields and raising plant resilience to environmental stress, according to a research by Chen et al. (2017) that found many compounds generated by S. viridochromogenes that were beneficial in encouraging the development of tomato plants.

Environmental applications

S. viridochromogenes' capacity to create enzymes and breakdown contaminants makes it useful for environmental applications.

According to one study by Zhu et al. (2018), S. viridochromogenes produces a cellulase enzyme that is efficient in dissolving cellulose, a significant component of plant cell walls. This enzyme could be useful in the synthesis of various bioproducts, such as biofuels, from plant biomass.

Another research by Yu et al. (2017) looked at S. viridochromogenes' capacity to break down the ubiquitous environmental contaminant phenol. S. viridochromogenes may be useful in the bioremediation of phenol-contaminated habitats, according to the scientists' discovery that it can breakdown phenol at a rapid pace under aerobic circumstances.

Additionally, it has been demonstrated that S. viridochromogenes produces enzymes that are efficient in degrading other environmental contaminants. According to a research by Yang et al. (2018), S. viridochromogenes produces an enzyme that is efficient in degrading polycyclic aromatic hydrocarbons (PAHs), which are harmful pollutants frequently found in soil and water. Potential uses for this enzyme include the bioremediation of PAH-contaminated settings.

S. viridochromogenes has been demonstrated to create enzymes that are efficient in biocatalysis in addition to its capacity to breakdown contaminants. A S. viridochromogenes enzyme was discovered by Liu et al. (2015) to be efficient in catalysing the synthesis of a chiral intermediate utilised in the manufacture of pharmaceuticals.

Conclusions

As a consequence, Streptomyces viridochromogenes is a multipurpose microbe with several uses in a variety of industries, including agriculture, medicine, and the environment. It has been demonstrated that the bacterium produces a wide range of bioactive substances, including antibiotics, immunosuppressive substances, antifungal substances, and enzymes, which may have uses in the treatment of diseases, plant protection and growth enhancement, and bioremediation of environmental pollutants.

Research on S. viridochromogenes has shed important light on the variety of applications this bacteria could find use in. To completely comprehend the mechanisms of action of the bioactive chemicals generated by this bacteria and to optimise their production and purification for useful applications, further study is nonetheless required. Research is also required to assess the effectiveness and safety of these substances in various contexts, such as clinical trials for prospective medicinal uses.

Overall, S. viridochromogenes is a strong candidate for more study and development across a range of sectors due to its adaptability and prospective uses. S. viridochromogenes has the potential to dramatically impact environmental science, agriculture, and medicine with further study and development.

Additionally, S. viridochromogenes and its bioactive substances may offer long-term answers to a variety of problems in several disciplines. S. viridochromogenes, for instance, can be used in agriculture to lessen the need for artificial fertilisers and pesticides, which can have detrimental effects on the environment and human health. Similar to this, using S. viridochromogenes in bioremediation might offer a sustainable way to clean up contaminated surroundings.

The study of S. viridochromogenes further emphasises the significance of discovering new natural products and studying microbial diversity. S. viridochromogenes is only one example of the numerous and mostly unexplored sources of microorganisms that may be used to find novel bioactive substances with a wide range of uses. Additional research into the variety of microorganisms may result in the identification of fresh antibiotics, immunosuppressive drugs, and other bioactive substances with potential medical and industrial uses.

In conclusion, Streptomyces viridochromogenes is a promising microbe with several uses in healthcare, agriculture, and environmental protection. The bacterium has been demonstrated to create a range of bioactive substances, which may find use in a number of different industries. To completely comprehend the mechanisms of action of these chemicals and to optimise their synthesis and purification for useful uses, more study is needed. S. viridochromogenes has the ability to greatly enhance science and technology via continued research and development while advancing environmentally friendly answers to a range of problems.

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