An Overview on Actinomycetes

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ABSTRACT: Indigenous marine actinomycetes are found in the seas and are extensively dispersed in various marine habitats, according to recent discoveries using culture-dependent and culture-independent techniques. The marine actinomycetes that live in aquatic settings are very diverse and unique. Novel actinomycetes have been isolated from materials obtained from various maritime settings and ecosystems. Different kinds of secondary metabolites are produced by these marine actinomycetes. Many of these metabolites have biological functions and may be used as medicinal treatments in the future. Marine actinomycetes are a rich source of new secondary metabolites that has been underutilized. Actinomycetes are Gram-positive bacteria with a fungal shape and a high GC. They include a large number of secondary metabolites with a wide range of biological activities. Gram-positive bacteria that belong to the phylum Actinobacteria, class Actinobacteria, subclass Actinobacteridae, order Actinomycetales, which has ten suborders, over 30 families, and over 160 genera.

KEYWORDS: Actinomycetes, Enzymes, Antibiotics, GC content.

INTRODUCTION

The Gram-positive bacteria are divided into two evolutionary groups: "low-GC" and "high-GC." The proportion of GC base pairs in an organism's DNA is referred to as GC content. Those with a low GC level have more AT base pairs in their DNA than those with a high GC content. Although GC content is a crude measure of microbe relatedness, it is nevertheless helpful for distinguishing major phylogenetic divisions. They have a diverse variety of life cycles that set them apart from other prokaryotes[1], [2]. Actinomycetes are a significant category of microbial resources with widespread practical use and high economic value. They generate a great number of non-antibiotic bioactive metabolites, such as enzymes, enzyme inhibitors, immunological regulators, anti-oxidation reagents, and so on. Actinomycetes may be found in a variety of natural environments, including soil and the ocean. Millions of microorganisms live in the sea, and they play an essential part in the mineralization of complex organic matter, the decomposition of dead plankton, plants, and animals, the degradation of pollutants and toxicants, and primary and secondary production. With new enzymes like amylase, lipase, deoxyribonuclease, lipase, and protease, marine microbes may catalyze a wide variety of metabolic reactions[3]–[6].

Actinomycetes' Occurrence and Habitats:

In most soils, actinomycetes make up a substantial portion of the microbial community. Actinomycetes counts of above 1 million per gram are frequent, according to estimates. Soil has been used to isolate over twenty genera. Streptomycetes were identified in 95% of the isolates, according to Lechevalier & Lechevalier (1967). The kind and number of actinomycetes in soil are influenced by environmental variables. In culture, most actinomycete isolates behave like neutrophils, with a pH range of 5.0 to 9.0 and an optimal pH of about 7.0.

Compost and other similar materials:

In the early phases of decomposition, several mesophilic actinomycetes are active in compost. However, obligatory and facultative thermophilic actinomycetes benefit from the ability to self-heat during decomposition. Thermoactinomycetes and Saccharomonospora, for example, are exclusively thermophilic genera. Animal dung is ideal for the growth of thermophilic actinomycetes. They've worked with pig feces fermentation, straw, and pig feces deodorization.

Marine environments include:

Early research on the microbial community of maritime environments included actinomycetes by chance. In such pioneering studies, selective isolation techniques and accurate diagnostic tests were not utilized. Actinomycetes are thought to make up a tiny percentage of the bacterial flora in marine environments, with low numbers compared to terrestrial and freshwater locations. Actinomycetes were thought to be part of an indigenous marine microflora by some researchers, but they were also thought to be wash-in components that only persisted as spores in marine and littoral sediments by others. The fact that the number of actinomycetes in maritime environments decreases as the distance from land increases supports the latter viewpoint.

Actinomycetes Characteristics and Nutrition:

In nature, actinomycetes are heterotropic. The majority are strict saprophytes, but others have parasitic or mutualistic relationships with other plants and animals. Actinomycetes are generally thought to have a role in nutrient recycling. Some are aerobic, whereas others, such as Actinomyces, are anaerobic. Frankia species require very specific growth medium and incubation conditions. Many actinomycetes thrive on standard laboratory bacteriological media including nutrition agar, trypticase agar, blood agar, brain heart infusion agar, and starch casein agar. Sporoactinomycetes need specialized conditions in order to differentiate and produce distinctive spores and colors[7]–[10].

Novel methods for isolating Actinomycetes:

When novel screening methods are used, it has been shown that previously undiscovered and significant natural compounds are discovered. Because of their sluggish development compared to other soil bacteria, isolating actinomycetes from mixed microflora in nature is difficult. For the isolation of industrially significant actinomycetes, there are four fundamental steps.

- *Substrate selection:* Actinomycetes have been isolated from both freshwater and marine environments. There must be some distinctions between species found in marine and terrestrial habitats. Some antagonistic actinomycetes, such as xanthomycin-producing actinomycetes, were isolated more often from shallow sea actinomycetes than from terrestrial soil throughout the screening process. Few of these actinomycetes were discovered to be novel, producing new antibiotics or physiologically active compounds when exposed to certain circumstances. As a result, isolating actinomycetes from marine environments provides another avenue for discovering novel actinomycetes and medicines.
- *Re-heat treatment:* A pretreatment that enables for the selective separation of an actinomycetes component that is usually uncommon or non-existent in soils. One such example is the rehydration of leaf litter from freshwater environments, which has resulted in the discovery of many actinoplanetes and the new species "Cupolomyces." Most actinomycetes' airborne spores are resistant to desiccation and can withstand both wet and dry heat. Gramnegative bacteria are substantially reduced when temperatures are kept at such low levels. Bioactive actinomycetes isolated from marine sediments may be well-separated using a combination of drying and moderate heat treatments, as well as selective media.
- *Incubation:* The bulk of antibiotic-producing actinomycetes thrive at temperatures between 25 and 30 degrees Celsius. Thermopiles are kept at 40 to 45 degrees Celsius, whereas psychrophiles are kept at 4 to 10 degrees Celsius. Isolation plates are typically incubated for 7 to 14 days. Longer incubation periods have been overlooked in the past because slow-growing actinomycetes would be poor candidates for commercial fermentation. Early development of certain bacteria species, on the other hand, may alter the nutritional environment of the isolation plate by providing growth factors. The incubation time may be prolonged for one month to isolate new actinomycetes.
- *Choosing a Colony:* The most time-consuming technique is colony selection. It is dependent on the screening program's goals. There may be a lot of colony duplication. More reasonable methods must be used to isolate bacteria. The majority of researchers now use a stereomicroscope to identify potential colonies and a pointed wooden cocktail stick to transfer growth. Small colonies may be identified and selected, and the rough wooden points contain enough spores or hyphal pieces to ensure a successful transfer. The collection location, knowledge of an isolate's secondary metabolite, objective enrichment methods, and objective culture medium formulations would all lead to the isolation of new and prospective isolates.

Importance of Actinomycetes in Biotechnology:

The enormous metabolic variety of actinomycetes, as well as their long connection with the environment, has led to increased interest in biotechnological applications. Actinomycetes are a distinct category of prokaryotic organisms with distinct morphological, cultural, biochemical, and physiological characteristics. This organization has the potential to generate antimicrobials, enzyme inhibitors, immunomodifiers, enzymes, and plant and animal growth promoters.

i. *Antibiotics:* Actinomycetes are the most prolific producers of antibiotics. Actinomycetes provide two-thirds of today's antibiotics. Anthracyclines, aminoglycosides, -lactams, chloramphenicol, macrolides, tetracyclines, nucleosides, peptides, and polyethers are all significant antibiotics produced by actinomycetes.

ii. *Xenobiotic Transformation:* The structural alteration of components alien to an organism's metabolism that occur in its chemical environment is referred to as xenobiotic transformation. Oxidative, reductive, hydrolytic, dehydration, and condensation are the most common xenobiotic transformation processes. The capacity of actinomycetes to conduct a range of microbial conversions of organic molecules is a key component in the complex processes of pollution biodegradation in soil and water.

iii. *Immunomodifiers:* Actinomycetes culture filtrates have yielded low molecular weight chemicals that boost immunological responses. Immunomodifiers are the term for such substances. Inhibitors of enzymes found on the surface of immune cells may attach to these cells and boost immunological responses. Streptomyces olivoreticuli bestatin, Streptomyces species ME 98-M-3 amastatin, and Streptomyces lavendulae phenicine all improved immunological responses in mice. Interleukin-2 production, mixed lymphocyte reaction, interferon, cytotoxic-T cells, and platelet activating factor-C induction are all inhibited more effectively by immunosuppressive agents like FR-900506 reported by Fujisawa pharmaceutical company, which is produced by Streptomyces tsukubaensis sp. Nov.

iv. *Biosurfactant:* A surface-active chemical generated by living cells, mostly microbes, is known as a biosurfactant. Any chemical produced by microorganisms that has some effect on surfaces has been referred to as a biosurfactant. Surface tension measurements are used to determine the effectiveness of biosurfactants. Surfactant and emulsifier are often used interchangeably in the literature.

v. *Inhibitors of Enzymes:* Actinomycetes produce low-molecular-weight enzyme inhibitors. A streptomycetes strain produced the first low molecular weight enzyme inhibitor, according to Umezawa. Over 60 inhibitors have been discovered since then, including leupreptins, which block papain, plasmin, and trypsin. Papain, chymotrypsin, trypsin, and cathepsin B are all inhibited by antipain. Enzyme inhibitors are being investigated as a potential cancer therapy. Reverse transcriptase is inhibited by revistin, an enzyme inhibitor found in Streptomyces species. Streptomyces synthesizes streptonigrin and retrostatin, which block reverse transcriptase. Alistragin, discovered in Streptomyces roseoviridis culture filtrates, inhibits carboxypeptidase B. S. tanashiensi produces phosphoamiden, which inhibits metallo-proteases.

Various Enzymes have Different Applications:

1. *Use of the -Amylase Enzyme:* - Amylases were the first enzymes to be commercially manufactured and sold. Dr. J. Takamine developed the first commercial synthesis of -amylase from A. oryzae, which was utilized as a digestive aid and was dubbed "Taka diastase." In 2004, the worldwide enzyme market was valued at about $ 2 billion. It is projected to increase at a pace of 3.3 percent on an annual basis. Carbohydrases, which include amylases, isomerases, pectinases, and cellulases, account for approximately 40% of all enzymes. 90% of the carbohydrases produced are used in the food and beverage industries. The worldwide market for - amylases is expected to be about $11 million per year. Throughout 300 tons of pure enzyme protein were produced each year from - amylases produced by B. licheniformis and Aspergillus sp. around the globe.
2. *Protease Enzyme Applications:* The following section covers the most common applications of alkaline proteases in industry. Industry of food and feed. Microbial proteases have long been used in the food industry for a variety of purposes. Protein hydrolysates with excellent nutritional value have been prepared using alkaline proteases. Protein hydrolysates are employed in baby food formulations, specialized therapeutic dietary items, and the fortification of fruit juices and soft beverages and play an essential role in blood pressure control. Proteases' primary job is to hydrolyze proteins, and this characteristic has been used for the production of high-nutrient protein hydrolysates. Alkaline proteases are employed to make hydrolysates from a variety of natural protein substrates.
    - *Industry of Leather:* The use of hydrogen sulfide and other chemicals in traditional leather manufacturing techniques pollutes the environment and poses a safety risk.
    - *Industry of Photography:* In the bioprocessing of old X-ray or photographic films for silver recovery, alkaline proteases are essential. The gelatin layer of these waste films contains 1.5–2.0 percent silver

by weight, making them an excellent source of silver for a number of applications. Traditionally, this silver has been retrieved by burning the films, which pollutes the environment. Furthermore, polyester-based base film cannot be recovered using this technique. Because the silver is linked to gelatin, proteolytic procedures may remove the silver from the protein layer. Enzymatic hydrolysis of gelatin not only aids in the extraction of silver, but it also allows for the recycling of the polyester film basis.

- *Usage in Medicine:* Alkaline proteases have also been utilized to create medicinal goods. For example, the elastolytic activity of B. subtilis 316M was used to make elastoterase, which was used to treat burns, purulent wounds, carbuncles, furuncles, and deep abscesses. Kim et al. described the use of Bacillus sp. strain CK 11-4 alkaline protease as a thrombolytic agent with fibrinolytic activity.

DISCUSSION

The order Actinomycetales contains a collection of aerobic and anaerobic microorganisms known as actinomycetes. These creatures are phylogenetically different, but visually identical, with filamentous branching structures that break down into bacillary or coccoid forms. Actinomycetes are the most valuable microbes in terms of both economics and biotechnology. Actinomycetes may be found in a variety of environments, including freshwater, seawater, cold-blooded and warm-blooded animals, and compost piles. The dirt, on the other hand, is their primary habitat. Over 20 genera have been identified from soil, with viable numbers of several millions per gram being typical. Antibiotics, antifungal, antiprotozoal, antiviral, anticholesterol, antihelminth, anticancer, and immunosuppressant secondary metabolites are all produced by actinomycetes.

CONCLUSION

Actinomycetes have been reported in the microbial community in maritime environments, although there have been relatively few studies on them. Furthermore, there is very little information on the presence and distribution of actinomycetes in the mangrove environment (which is one of the most productive coastal ecosystems). Indigenous marine actinomycetes are found in the seas and are extensively dispersed in various marine habitats, according to recent discoveries using culture-dependent and culture-independent techniques. The marine actinomycetes that live in aquatic settings are very diverse and unique. Novel actinomycetes have been isolated from materials obtained from various maritime settings and ecosystems. Different kinds of secondary metabolites are produced by these marine actinomycetes.

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