Bio Prospecting of Marine-derived *Streptomyces spectabilis* VITJS10 and Exploring its Cytotoxicity Against Human Liver Cancer Cell Lines

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**ABSTRACT**

**Background:** Recently, numerous pathogens have developed resistance due to the indiscriminate use of commercial therapeutic drugs. In response, many species of marine origin have been investigated for antimicrobial and cytotoxic properties.

**Materials and Methods:** The *S. spectabilis* VITJS10 ethyl acetate extract was tested for antibacterial, antioxidant, and cytotoxic properties. Gas chromatography–mass spectrometry (GC-MS) was used for genotypic characterization.

**Results:** The antibacterial potential revealed effective activity against *Shigella flexneri* (MTCC No: 1457) (22 mm), *Salmonella typhi* (MTCC No: 1167) (23 mm), *Escherichia coli* (MTCC No: 1588) (22 mm), *Pseudomonas aeruginosa* (MTCC No: 4676) (22 mm) at 20 mg/mL concentration. Scavenging ability of the extract was determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay revealing its 95% inhibition at 5 mg/mL concentration. Hepatocellular cancer cells (HepG2) cell line was used to evaluate the cytotoxicity by tetrazolium bromide assay. The extract showed maximum inhibition at IC50 of 250 μg/mL with 53.6% cell viability.

**Conclusion:** Hence the present study justifies the overwhelming circumstantial evidence as the most bioactive metabolites from the marine origin, which has potential utilization in pharmaceutical industry.

**Key words:** Bioactivity, cytotoxicity, MARINE actinomycetes, secondary metabolites, *Streptomyces spectabilis*, VITJS10

**SUMMARY**

- The aim of this study was to explore the bioactive potential of marine Streptomyces sp. isolated from marine soil and understand the bioactive properties of the crude extracts. It is clearly evident from the study that the bioactive metabolites produced by Streptomyces sp. exhibited good antibacterial, antioxidant and anticancer activity. Our results indicated that Starch casein medium was the good base for bioactive metabolite production.

**INTRODUCTION**

Cancer is a leading cause of death worldwide, accounting for approximately 1/8 of all deaths.1 Moreover, antimicrobial resistance causes more extensive morbidity and premature death in infected patients. There is certainly an urgent need for new antimicrobial agents, given the rise in drug resistance in common bacterial pathogens and changes in the spectrum of pathogens. Research strategies for the discovery of new antimicrobial drugs are heavily influenced by the need to discover and develop new agents active against organisms resistant to earlier generations of drugs. Anticancer drugs from marine origin have received much attention in recent years. It is increasingly evident that the true biological origin of many metabolites originally isolated from certain marine microorganisms. Secondary metabolites from marine actinomycetes have been extensively reviewed recently, demonstrating their structural diversity and emphasizing their promising potential as pharmaceuticals and to enable enhanced detection of novel chemical class of antibiotics. The discovery of new active metabolites must be followed by adequate biological testing.2 Hence the present study was focused to characterize the *Streptomyces spectabilis* VITJS10 crude extract for its biological potential.

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MATERIALS AND METHODS
Sample collection, isolation, and characterization of marine actinomycetes
Marine soil samples were collected from south-east coast of Tamil Nadu, India, Kanyakumari – Chinnamuttom (Lat. 8°5’S and 77°39’E), at the depth of 50 cm at littoral zone. The isolation of Actinobacteria was performed on starch casein agar. The morphological and cultural characteristics of the potent strain were determined on various ISP medium.[3,4] The spore morphology was observed under a light microscope and scanning electron microscopy (SEM) (FEI QUANTA; FEG 200). The morphological identification was done on the basis of nonomura guidelines.[4,5]

Cross streak assay
The strain Streptomyces sp VITJS10 was cross streaked on modified nutrient glucose agar against wide range of clinical pathogens namely Shigella flexneri (microbial type culture collection and Gene Bank [MTCC] No: 1457), Salmonella typhi (MTCC No: 1167), Escherichia coli (MTCC No: 1588), Staphylococcus aureus (MTCC No: 7405), and the zone of inhibition was measured after 2 days of incubation.[6]

Production
The inoculum of the potent strain Streptomyces sp VITJS10 was prepared on starch casein broth at an incubation period of 7 days at room temperature. Simultaneously the culture filtrate was extracted with ethyl acetate and concentrated by using a rotary evaporator.[7] The extract was then air dried to solid residue and tested for bioactive potential.

Antibacterial activity
The in vitro antibacterial activity of the strain Streptomyces sp VITJS10 crude extract was determined by agar well diffusion method.[8]

Antioxidant activity
The antioxidant activity was determined by 2,2-Diphenyl-1-picylhydrazyl (DPPH) scavenging assay. Various concentrations (0.1, 0.5, 1.0, 3.0, and 5.0 mg/mL) of Streptomyces sp VITJS10 crude extract was taken in separate tubes. Ascorbic acid was used as a reference compound (0.1, 0.5, 1.0, 3.0, and 5.0 mg/mL). A freshly prepared solution of 0.002% DPPH in methanol was added to each tube containing different concentrations of extracts (2.0 mL). The samples were incubated in dark at 37°C for 20 min and read at 515 nm. The data was expressed as the percent decrease in absorbance compared with the control. The percentage inhibition of radical scavenging activity was calculated.[9]

Maintenance of cell cultures
The hepatocellular cancer cells (HepG2) were obtained from NCSS, Pune and cultured in RPMI-1640 medium on 10 cm tissue culture dishes (Greiner Bio-one*, Germany) supplemented with 10% heat inactivated fetal bovine serum (FBS). Cells were incubated in humidified incubator with 5% CO₂ at 37°C for 48 h; 20 μL of 5 mg/mL MTT diluted in phosphate-buffered saline (PBS) were added to each well and incubated for 4 h. One hundred microliter of 10% Sodium dodecyl sulfate (SDS) in 0.01 M Hydrochloric acid solution was added to each well to dissolve the formazan crystals formed. The plates were covered with aluminum foil and kept in an incubator for 12 h for dissolution of the formed formazan crystals. Amount of formazan was determined measuring the absorbance at 560 nm using a micro plate reader.[10]

16S r DNA sequencing
Total genomic DNA was isolated using the phenol chloroform method.[11] Polymerase chain reaction (PCR) amplification of 16S r-DNA was carried out using the primers. Sequencing was performed using big dye terminator cycle sequencing kit (Applied BioSystems, USA). The sequence data was submitted to the GenBank database under the accession number KJ636987. The phylogenetic tree was constructed via the neighbor-joining method using the EvolView program.[12]

Gas chromatography–mass spectrometry analysis
The crude extract of Streptomyces sp VITJS10 was subjected to gas chromatography–mass spectrometry (GC-MS) for the detection of volatile compounds. The analysis was performed using GC SHIMADZU QP2010 system.[13] NIST08 and WILEY8 database was used for the identification of the separated peaks. The diversity of compounds was indicated by the metabolite profiles.

RESULTS
Marine actinomycetes are the richest source of bioactive compounds used in modern medicine as pharmaceutical intermediates. Microbial derived metabolites have recently attracted great interest, owing to their novel chemical structures and bioactivities.

Table 1: Streptomyces spectabilis VITJS10: Morphological, physiological, and biochemical properties

| Carbon source | Nitrogen sources |
|---------------|------------------|
| D-glucose     | ++               |
| Sucrose       | -                |
| D-galactose   | +                |
| Mannose       | +                |
| Maltose       |                  |
| Lactose       | -                |
| Mannitol      | -                |
| L-riboflavin  | +                |
| Arabinose     | -                |

| Effect of temperature | Effect of pH | Effect of NaCl tolerance |
|-----------------------|--------------|--------------------------|
| 15°C                  | 5            | 0.3%                     |
| 28°C                  | 6            | 1%                       |
| 37°C                  | 7            | 2%                       |
| 45°C                  | 7            | 3%                       |
| 50°C                  | 7            | 4%                       |
| 60°C                  | 8            | 5%                       |

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their versatile applications. The strain VITJS10 was studied on the basis of its morphology and recognized by their presence of aerial hyphae with reddish orange color [Table 1]. The colonies with powdery appearance had a characteristic feature of warty surface with spiral chains under SEM (magnification 6000×) with spore diameter of 0.6 μm [Figure 1a and b]. The biochemical and taxonomical characterization represented the features of Streptomycetaceae family. The antibacterial activity was screened and confirmed through cross streak assay against the pathogens showing broad spectrum [Figure 2]. The ethyl acetate extract showed broad spectrum antimicrobial activity toward Gram-positive and -negative bacteria at the concentration of 20 mg/well against S. flexneri MTCC No: (1457) (22 mm), S. typhi MTCC No: 1167 (23 mm), E. coli MTCC No: 1588 (22 mm), Pseudomonas aeruginosa MTCC No: 4676 (22 mm) [Figure 3A and B]. The crude extract studied for its antioxidant activity at different concentrations displayed highest degree at 5 mg/mL with 95% inhibition [Figure 4a and b]. The hemolytic property of the S. spectabilis VITJS10 crude extracts revealed maximum zone of lysis with 15 mm. The S. spectabilis VITJS10 crude extracts was also found to exhibit significant anticancer activity against HepG2 with the inhibition rate of 53.6% at concentration of 250 μg/mL. The positive control doxorubicin (5 μg/mL), which was used as internal positive control, showed 94% cell lysis at concentration of 250 μg/mL. The HepG2 cells was noticed with highest percentage of cell death [Figure 5]. The 16S rDNA sequence revealed the highest similarity to S. spectabilis S3-1 with 99%. Further the isolate VITJS10 was named as Streptomyces spectabilis VITJS10 [Figure 6]. The chemical constitutes of S. spectabilis VITJS10 crude extract revealed 37 chemical compounds; out of which, 3 important components were identified. The major chemical structures namely Sulfurous Acid, 2-ethylhexyl tridecyl ester were noticed with the retention time (RT) at 6.16 min showing peak at m/z 376 [M] + in accord with the molecular formula, C_{21}H_{44}O_{3}S. Phenol, 2,4-bis (1,1-dimethylethyl) (MW-206) Formula- C_{14}H_{22}O, which showed its RT at 13.20 min, Trans-2-methyl-4-n-pentylthiane, S, S-Dioxide, RT at 14.1 min: (MW218) C_{11}H_{22}O_{2}S [Figure 7]. The study justifies that marine Streptomyces provide a number of metabolites when compared with other bacteria. Hence the study showed significance results as promising targets for the development of cytotoxic and antimicrobial drugs.
DISCUSSION

Recently, much attention has been directed toward biologically active compounds isolated from marine saltern. The natural products have been shown to have antioxidant activity and are capable of scavenging free superoxide radicals, thus reducing the risk of cancer.\(^{[15]}\) One of the more significant findings emerge from this study is that the *S. spectabilis* VITJS10 extract exhibited a promising anticancer activity on human liver cancer cell lines. Several mechanisms were found to underlie these multifaceted synergistic activities of the active principles. The potential of antimicrobial and anticancer activity perhaps would be due to the presence of the parental compounds in the crude extract showing distinctly synergistic effects. Similarly, most of the bioactive molecules isolated from Actinobacteria are cytotoxic: Streptazone B1 produced by strains HB117, HB122, and HB291.\(^{[16]}\) Fredericamycin A (produced by strains HB116, HB118, and HB157).\(^{[17]}\) The present study has shown the beneficial effects of the *S. spectabilis* VITJS10 synergistic compounds. Further studies are needed to confirm in large, rigorous trials. Hence the advantages of natural compounds are known with fewer side effects in comparison to orthodox medical drugs, which indicate more specific for the positive treatment outcome.

CONCLUSION

*Streptomyces spectabilis* VITJS10 showed various bioactive properties, which highlighted its importance as potential pharmacological agents. Hence, there could be probability of new bioactive compound in the crude extract, which might provide a basis for further development of novel compound. This also provided a new insight toward the development of good candidates for pharmaceutical and bioactive natural products.
Figure 7: Gas chromatography–mass spectrometry chromatogram of Streptomyces spectabilis VITJS10 crude extract

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Conflicts of interest
There are no conflicts of interest.

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