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Isolation of Cellulose Producing Marine *Streptomyces Sp.* from Sediment Samples and their Antioxidants Properties

Arunn Jaikumarr Ram, Sivaperumal Pitchiah*, Anitha Roy, Lakshmi Thangavelu

Department of Pharmacology, Saveetha Institute of Medical and Technical Sciences, Saveetha University, India

ABSTRACT

Cellulase generated by cellulolytic bacteria helps to degrade the cellulose. This enzyme is considered a major industrial enzyme group and has several industrial applications. The bioconversion of renewable cellulose biomass to commodity chemicals is a potential challenge area where cellulase plays a central role. Marine Streptomyces species are drawing more and more attention as a promising source of new natural products. Oxidation causes Endothelial stress which is ultimately involved in endothelial dysfunction, which is obvious in adults with different cardiovascular conditions, including thalassemia. The sediment sample was collected from the Thondi area, Tamilnadu. The collected sample was sun dried for 48 hrs. and turned into fine powder by mortar and pestle. The actinobacteria was isolated and identified the marine actinobacteria with the help of aerial mass colour, melanoid pigments, reverse side pigments, soluble pigments, and spore chain morphology. Chemotaxonomic characteristics and scanning of cellulase production were done and showed potential antioxidant properties. The effect of pH and temperature on cellulase enzyme production were analysed and their potential antioxidant properties also done.

Key words:
Marine Streptomyces, Enzyme, Cellulase, Antioxidant activity

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Corresponding author: Sivaperumal Pitchiah
e-mail ✉ : sivaperumalp.sdc@saveetha.com
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INTRODUCTION

The most important agricultural waste in the world is cellulose and is an abundant natural biopolymer. This cellulosic biomass is a rich, renewable resource with a high bioconversion potential to value-added products [1]. Cellulase generated by cellulolytic bacteria helps to degrade the cellulose. This enzyme is considered a major industrial enzyme group and has several industrial applications [2]. Moreover, in the textile industry, the most important industrial application of cellulases is bio-polishing textiles and stoned denims as well as laundry detergents for home laundry in order to improve fabric softness and shine [3]. In addition, they are used in animal feed for improved nutritional quality and digestibility, fruit juice processing as well as in the baking process [4]. The bioconversion of renewable cellulose biomass to commodity chemicals is a potential challenge area where cellulase plays a central role [5].

Marine *Streptomyces species* are drawing more and more attention as a promising source of new natural products [6]. Actinomycetes bacteria of genus *Streptomyces* are one of the most promising biological sources for new natural products and will continue, at least for the near future [7]. The intensive investigation of terrestrial actinomycetes in 1950-1970 did lead to the frequent reconstruction of bioactive compounds, attracting attention to new, ecological niches that could have been sources of new actinomycetes [8].

As the sea accounts for more than 70 percent of the surface of the world and hosts about 87 percent of the world's biodiversity, the findings of new microorganisms, including actinomycetes, appear largely undeveloped. Given the never seen diversity of marine organisms and the relatively little work done to date, more than 25000 new marine natural products have now been identified as astounding [9]. Many such compounds come from deep sea sediments, coral reefs, aquatic invertebrates and plants isolated from marine actinomycetes [10,11].

Various marine actinomycetes compounds have a significant potential to become pharmaceutical drugs. Diazepinomicin, a marine micromonospora dibenzodiazepine alkaloid, has had antibacterial and anti-tumor activities, and had glioblastoma treatment clinical studies in Phase II [12,13].

Some important papers which were done by the researchers helped in this study. Some of them are regarding the antioxidant [14,15], anti-inflammatory

[16,17] and antidiabetic properties [18-20]. Papers about anticancer were also [21,22] helpful.

As toxic and beneficial compounds, free radicals and oxidants can play a dual role, since they can be damaging or helpful for the body. The development of many human diseases has been involved. Among them, arthritis, inflammatory diseases, kidney diseases, cataracts, inflammatory bowel disease, colitis, lung dysfunction; pancreatitis are the most common [23]. Oxidation causes endothelial stress which is ultimately involved in endothelial dysfunction, which is obvious in adults with different cardiovascular conditions, including thalassemia [24]. Red blood cells are protected against oxidant damage by antioxidants and other supportive treatments [25]. Further, our team has extensive knowledge and research experience that has translated into high quality publications [26-46]. This study aims at isolation of cellulase producing marine *Streptomyces sp*. from sediment samples and their antioxidant properties.

MATERIAL AND METHOD

Sample collection and preparation

The sediment sample was collected from the Thondi area, Tamilnadu. The collected sample was sun dried for 48 hrs. and turned into fine powder by mortar and pestle.

Isolation of actinobacteria

Aerial mass colour:

The colour of the mature sporulating aerial mycelium was recorded in naked eye. When the aerial mass colour fell between two colours series, both the colours were recorded. If the aerial mass colour of a strain to be studied showed intermediate tints, then also, both the colour series were noted. The media used were Yeast Extract-Malt Extract Agar and Inorganic-Salt Starch Agar.

Melanoid pigments:

The grouping was made on the production of melanoid pigments (i.e. Greenish brown, brownish black or distinct brown, pigment modified by other colours) on the medium. The strains were grouped as melanoid pigment produced (+) and not produced (-). In a few cases, the production of melanoid pigments was delayed or weak, and therefore, it was not distinguishable. This is indicated as variable (V). This test was carried out on the media ISP-1 and ISP-7 (Appendix I), as recommended by the International *Streptomyces* Project (Shirling and Gottlieb, 1966).

Reverse side pigments:

Reverse side pigment production of the isolate was determined on ISP7 medium. The pigment production was noted as distinctive (+) and not distinctive or none (-). In case, a colour with low Chroma such as pale yellow, olive or yellowish brown occured, it was included in the latter group (-).

Soluble pigments:

Soluble pigment production of isolate was observed on ISP7 medium. The diffusible pigment production other than melanin was considered positive (+) and not produced (-). The colour was recorded (red, orange, green, yellow, blue and violet).

Spore chain morphology:

Spore morphological characters of the strains were studied by inoculating a loopful of one week old cultures into solidified agar medium contained sterile glass slide. The cultures were incubated at 28 ± 20oC and examined periodically for the formation of aerial mycelium, sporophore structure and spore morphology.

Chemo taxonomical characteristics

Hydrolysis

Hydrolysis was done for releasing amino acids. Harvested cells of each strain weighing 20 mg (fresh) were placed in an ampo bottle and 1 ml of 6 N HCl was added and sealed with an alcohol blast burner. The samples were kept at 1210 C for 20 h in a sand bath. The bottles were cooled by keeping them at a room temperature of 28+20C. Hydrolysis was also done for releasing sugars. Harvested cells of each strain weighing 50 mg (fresh) were placed in an ampo bottle and 1 ml of 0.5N HCl was added and sealed with alcohol blast burner. The samples were kept at 1100oC for 2h. The bottles were then cooled by keeping them at a room temperature of 28±20oC.

Thin Layer Chromatography (TLC)

Spotting of the whole cell hydro lysates was made carefully on TLC plate using a microliter pipette. Spots were 5-10 mm in diameter. This was done by multiple applications on the same spot of very small portions of the sample, which were dried by a hand dryer.

Amino acids

Each sample (3 µl) was applied on the baselines of the TLC plate (20 cm x 20 cm). Adjacent to this, 1µl of DL-diaminopimelic acid (an authentic material mixture of DAP isomers) and 1µl of amino acetic acid (glycine) were spotted as standards. TLC plate was developed with the solvent system containing methanol: pyridine: glacial acetic acid: H2O (5: 0.5: 0.125: 2.5 v/v). It took approximately more than 4 h for development. The spots were visualized by spraying with 0.4% ninhydrin solution in water-saturated n-butanol, followed by heating at 1000 C for 5 min. Spots of amino acids ran faster than DAP. The sample spots were immediately compared with the spots of the standards since spots gradually disappeared in a few hours.

Whole-Cell sugars

On a cellulose TLC plate (20 cm x 20 cm), 5µl of samples was spotted along with 3 µl of sugar solutions as standards on the same plates. Galactose, arabinose, xylose and madurose were the sugars, which were used as standards. TLC plate was developed with the solvent mixture containing ethyl acetate: pyridine: acetic acid: distilled water (8: 5: 1: 1.5 v/v). The developing time was

more than 4 h. Spots were visualized by spraying with aniline phthalate reagent (3.25 g of phthalic acid dissolved in 2 ml of aniline and made upto 100 ml with water saturated n-butanol). The sprayed plate was heated at 1000 C for 4 min. Hexoses appeared as yellowish brown spots and pentoses, as maroon coloured spots.

Assimilation of carbon source

The ability of the actinobacterial strain in utilizing various carbon compounds as source of energy was studied, following the method recommended by International *Streptomyces* Project (Shirling and Gottlieb, 1966). Chemically pure carbon source certified to be free of admixture with other carbohydrates and contaminating materials were used for this purpose. Carbon sources for this test were Arabinose, Xylose, Inositol, Mannitol, Fructose, Rhamnose, Sucrose and Raffinose. These carbon sources were sterilized by ether sterilization without heating. The media and plates were prepared and inoculated according to the convention of ISP project (Shirling and Gottlieb, 1966). For each of the carbon sources, utilization is expressed as positive (+), negative (-), or doubtful (±). In the 'doubtful ' strains, only a trace of growth slightly greater than that of the control was noticed.

Screening of Cellulase Production

Cellulase activity of the strains was screened qualitatively in CMC (Carboxymethyl Cellulose) agar medium. After inoculation, the plates were incubated at 37oC for 5 days. To visualize the hydrolysis zone, the plates were flooded with an aqueous solution of 0.1% Congo red for 15 min and washed with 1 M NaCl. To indicate the cellulase activity of the organisms, diameters of clear zones around colonies on CMC agar were measured.

Determination of enzyme activity

The medium was inoculated with 1 ml of spore suspension of a 7 days old culture and incubated in rotary shaker (150rpm) at ambient temperature for three days. The cell free supernatant was collected by centrifugation at 12,000rpm for 15 min. The supernatant was the enzyme source. The substrate 2% of carboxymethyl cellulose solution (CMC) was prepared with a 50mM phosphate buffer (pH 7). 1ml of crude enzyme was added with 1ml of CMC solution which incubated for 60min at (50ºC) desired temperature. After incubation 2ml of 3, 5-dinitrosalicylic (DNS) reagent was added to terminate the enzyme reaction. After termination of enzyme activity all samples should be incubated for 5min at boiling temperature then the samples transferred to an ice cold water bath. After pulp settlement, the aqueous layer was e by centrifuge (12000 rpm/min for 5min at 4ºC) and the optical density was measured at 540nm. One International Unit (IU) of enzyme activity for cellulase was defined as the amount of enzyme releasing 1 µmol reducing sugar from CMC per minute using glucose as standard.

Effect of pH on enzyme production

The isolates were inoculated in CMC broth and the medium pH was adjusted from 6 – 8. The confirmation of growth was observed at 600nm. The enzyme production was quantified by the method described before.

Effect of Temperature on enzyme production

Effect of temperature on the cellulase enzyme production was analyzed by adjusting from 25, 30, 35, 40 and 50ºC. The isolate was inoculated in CMC broth and incubated at various ranges of temperature. The cell growth was confirmed by the absorbance at 600nm. The enzyme production was quantified by the method described before.

RESULTS AND DISCUSSION

The rise of widespread antibiotic- resistant bacteria heightened the need to discover new antimicrobial agents. Actinomycetes, especially *Streptomyces s*p., have attracted a lot of attention because they produce a lot of useful bioactive metabolites. Isolating these species from less -explored environments may improve the chances of discovering new microbial species. Isolation of cellulase producing *Streptomyces* from marine sediments sample and effect of physical factors on enzyme production (Tables 1-5). This study isolated marine actinobacteria from a sediment sample and identified *Streptomyces* genus from the isolate using specific characteristics of the bacteria. Then the production of enzyme was confirmed by screening for cellulase and enzyme assay was carried out. The enzyme assay revealed that the Carboxymethyl cellulase agar flooded with iodine, the total activity of the enzyme was 127.41 IU/mg. The effect of temperature and pH enzyme production was studied on CMC broth. It was found that the optimum pH and temperature for maximum enzymatic activity was and respectively. It was also observed that as the temperature increased, the enzymatic activity increased. However at the highest temperature, the rate decreased again which might probably be due to enzyme degeneration. Finally, antioxidant testing was performed which showed positive results (Figures 1-2).

Table 1: Conventional Identification of marine Streptomyces.

Color of aerial mycelium	White
Melanoid pigment	-
Reverse side pigment	+

Soluble pigment	-
Spore chain	RA
Assimilation of carbon source	
Arabinose	+
Xylose	+
Inositol	+
Mannitol	+
Fructose	+
Rhamnose	+
Sucrose	+
Raffinose	+

Table 2: Chemo taxonomical characteristics of marine *Streptomyces sp.*

Cell wall amino acids			Cell wall sugar		Cell wall type	Index
LL-DAP	Meso DAP	Glycine	Arabinose	Galactose	I	Streptomyces

Table 3: Depicts the effect of pH and effect of temperature.

Effect of Temperature	IU/ml	Effect of pH	IU/ml
25	11.79 ± 2.3	6	5.29 ± 2.2
30	13.52 ± 2.7	6.5	7.24 ± 2.5
35	16.47 ± 2.5	7	9.51 ± 2.1
40	12.18 ± 2.9	7.5	12.62 ± 2.9
50	10.25 ± 2.4	8	13.58 ± 2.3

Table 4: Depicts the DPPH scavenging at different concentrations.

Concentration (µg/ml)	DPPH Scavenging	Standard
25	11.07 ± 1.5	37.3 ± 1.27
50	18.24 ± 1.9	62.7 ± 1.31
75	31.35 ± 1.4	78.52 ± 1.28
100	42.18 ± 1.8	83.59 ± 0.78
125	55.46 ± 1.4	92.4 ± 1.26
150	68.09 ± 1.7	98.6 ± 1.24

Table 5: Depicts the Nitrous oxide scavenging at different concentrations.

µg/ml	Nitrous oxide scavenging	Std
25	12.37 ± 1.4	30.38 ± 1.127
50	25.64 ± 1.8	51.92 ± 1.164
75	32.91 ± 1.4	70.34 ± 1.152

100	47.64 ± 1.9	82.17 ± 1.231
125	58.27 ± 1.7	90.53 ± 1.204
150	73.59 ± 1.4	95.68 ± 1.168

Figure 1: Streptomyces sp.

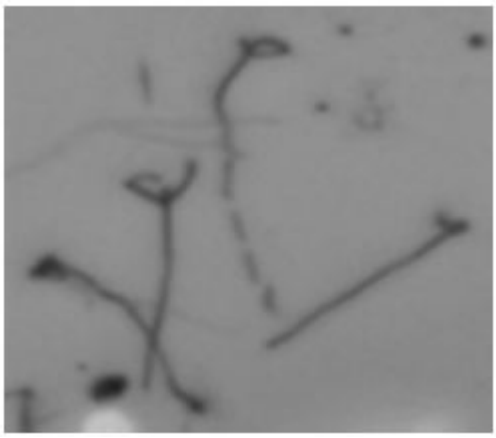

Figure 2: Spore chain morphology.

CONCLUSION

The present study was isolated and identified the marine actinobacteria of *Streptomyces sp*. From marine sediment samples. The conventional identification of chemotaxonomic characteristics was done and further scanning of cellulase production was also done. The marine actinobacterial cellulase showed potential antioxidant properties. The effect of pH and temperature on cellulase enzyme production was also analysed. The outcome of the present work concluded that marine actinobacterial enzymes can act as natural products and it could be useful in the biomedical sector.

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CONFLICT OF INTEREST

There are no conflicts of interest.

SOURCE OF INTEREST

Self.

ETHICAL CLEARANCE

Not Required.

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