

Production and Characterization of Antimicrobial Metabolites from *Streptomyces rochei* Strain SC1 against Multi-Drug-Resistant *Escherichia coli*

Sanjay Chavan*, Bhagvat Lad, Tukaram Kadam

Department of Microbiology, School of Life Sciences, S.R.T.M. University, Nanded, Maharashtra, INDIA.

ABSTRACT

Objectives: *Streptomyces rochei* have ability to synthesize a variety of antimicrobial compounds which exhibit antibacterial, antifungal, and even anticancer activities. *S. rochei* may have ability to produce bioactive compounds which will be effective against MDR pathogens. **Materials and Methods:** In the present investigation bioactive compound producing *S. rochei* was isolated from forest soil and identified by 16S rRNA gene sequencing. The potent *S. rochei* strain was used for production of bioactive compound, the bioactive compound was extracted using ethyl acetate, n-butanol and chloroform. The bioactivity of crude compounds was checked against MDR *E. coli* strains. The MDR *E. coli* are well known for causing infections in humans viz. diarrhea, urinary tract infections, sepsis, meningitis and bloodstream infections. The bioactive compounds present in n-butanol extract were purified by using column chromatography. The fraction showing maximum antimicrobial activity against MDR *E. coli* was structurally elucidated using UPLC-UV-MS. The *S. rochei* was isolated from forest soil sample on SCA and identified by using 16S rRNA sequencing as *Streptomyces rochei* and it was deposited in GenBank under Accession No. PQ637672. **Results:** The n-butanol extract of *S. rochei* showed maximum inhibitory activity against MDR *E. coli*. The 3rd fraction showed maximum antimicrobial activity was characterized by UPLC-UV-MS. The purified compound being identified as 10-deoxymethynolide (C₁₇H₂₈O₄) having mass 296.1993 and Decylubiquinol (C₁₉H₃₂O₄) having mass 324.2306 from class Macrolide and Hydroquinone respectively. **Conclusion:** These compounds had showed growth inhibiting activity against MDR *E. coli*.

Keywords: Bioactive compound, *Escherichia coli*, *Streptomyces rochei*.

Correspondence:

Dr. Sanjay Chavan

Department of Microbiology, School of Life Sciences, S.R.T.M. University, Nanded-431606, Maharashtra, INDIA.
Email: sanjaychavan5551@gmail.com
ORCID: 0009-0005-4221-7827

Received: 12-09-2025;

Revised: 28-10-2025;

Accepted: 02-12-2025.

INTRODUCTION

Streptomyces rochei is a soil-dwelling, Gram-positive actinobacterium belonging to the genus *Streptomyces*, which is renowned for its complex secondary metabolism and ability to produce a wide variety of bioactive compounds, particularly antibiotics, enzyme inhibitors, antifungals, and potential anticancer agents.^[1] *S. rochei* produce compounds with antibiotic like properties viz. Lankamycin a macrolide antibiotic has broad spectrum activity against gram positive and gram-negative bacteria, Streptothricin an aminoglycoside-like antibiotic effective against both Gram-positive and some Gram-negative bacteria, Lankacidin a polyketide antibiotic effective against gram positive bacteria.^[2-4] The pathogenic *E. coli* strains are responsible for causing diarrhoea, dysentery, gastroenteritis, pneumoniae,

meningitis, bladder infection and urinary tract infection to human.^[5] The most commonly prescribed antibiotics to treat infection caused by pathogenic *E. coli* strains are antibiotics from class β -lactam, cephalosporin, sulphonamide, nitrofurantoin, quinolones, macrolides, glycopeptides, polymyxin and synthetic antibiotics oxazolidinones.^[6]

The UTI infection causing MDR *E. coli* strains are showed resistant to these antibiotics which in turn leads to increase in the cost of treatment, morbidity and mortality rate of patients.^[7] At present, most of the antimicrobials used to treat infection caused by MDR *E. coli* are not effective and even not free from adverse effect hence the novel species of *S. rochei* having ability to produce anti-MDR *E. coli* bioactive compounds will be promising to treat the patient infected by MDR *E. coli*.^[8,9] *S. rochei* is a major antimicrobial compound producer due to their prolific genetic and biochemical diversity and surviving ability in extreme environmental condition.^[10] Therefore, in the present investigation *S. rochei* from forest soil will be isolated and identified. The potent antimicrobial producing *S. rochei* will be used for production of bioactive compound, the bioactive



ScienScript

DOI: 10.5530/ajbls.20250054

Copyright Information :

Copyright Author (s) 2025 Distributed under Creative Commons CC-BY 4.0

Publishing Partner : ScienScript Digital. [www.scienscript.com.sg]

compound will be extracted and screened for antimicrobial activity against MDR *E. coli*. The purified bioactive compounds from crude bioactive extract will be structurally elucidated.

MATERIALS AND METHODS

Collection of soil samples and isolation of actinobacteria from soil samples

The soil samples were collected from Painganga forest, Umarched Dist. Yavatmal (M.S.), India. The 1 gm of collected soil samples were suspended in 10 mL sterile saline and serially diluted up to 10^{-4} to 10^{-5} .^[11] From these dilutions 0.1 mL of soil suspensions were spreaded on Starch Casein Agar (SCA), 50 µg/mL of nystatin was added to prevent the growth of the fungus. All plates were incubated at 28°C for 8 days.^[12]

Antimicrobial Activity and Screening of Actinobacteria

Primary screening of Actinobacterial isolates

A total of 17 Actinobacterial isolates were enriched in the 10 mL of SCB for 4 days at 28°C. After enrichment each isolate were inoculated into 100 mL of SCB, these broths were incubated on a rotatory shaker at 120 rpm, at 28°C for 8 days respectively. All the fermented broths were centrifuged at 4°C for 10 min at 10,000 rpm, supernatant was collected and these supernatants were used to check the bioactivity.^[13] Muller Hinton Agar (MHA) was prepared and labelled them accordingly. After solidification of agar, active 100 µL of MDR *E. coli* (PP854585), *E. coli* (PP854586) and *E. coli* (PP854587) cultures were spreaded on agar plates.^[14] 6 mm wells were punched by sterile cork-borer, 50 µL of supernatant of actinobacterial isolates were added to wells labelled, standard antibiotic ciprofloxacin (100 µg/mL) as positive control and DMSO as negative control were added and plates kept at 4°C for 10 min for diffusion. After diffusion, plates were incubated for 48 hr at 37°C.

Production and Extraction of Bioactive compound

The 6 Actinobacterial isolates SBCP-1, SBCP-2, SBCP-3, SBCP-4, SBCP-5 and SBCP-6 exhibited inhibitory activity against MDR *E. coli* in the primary screening were used for secondary screening. 10% inoculums of the selected 6 Actinobacterial isolates were inoculated in 500 mL pre-sterilized SCB in conical flasks separately followed by incubation at 28°C in an orbital shaking incubator at 120 rpm for 7 days. Fermented broths were centrifuged at 4°C for 10 min at 10,000 rpm, supernatant was collected. The bioactive metabolite from the supernatant was extracted by using three solvents such as Ethyl acetate, n-butanol, and Chloroform. 150 mL of supernatant was taken in separating funnel with equal amount of ethyl acetate (1:1). Gentle mixing was done for 30 min, after proper shaking the broths were allowed to settle and separate in which two layers formed upper was of organic and lower was of aqueous. Organic layer was collected in evaporation bowl

and allowed to evaporate after evaporation bioactive metabolite were collected and dissolved in DMSO, obtained residue was used to determine antimicrobial activity.^[15,16] Same procedures were repeated for chloroform and n-butanol for extraction of metabolite.

Secondary Screening of Potent Actinobacterial isolates

Muller Hinton agar was prepared, labelled them accordingly, active 100 µL of MDR *E. coli* (PP854585), *E. coli* (PP854586) and *E. coli* (PP854587) cultures were spreaded on respective agar plates.^[14] Wells were punched by sterile cork-borer. 50 µL of Actinobacterial ethyl acetate, n-butanol, and chloroform extract were added to wells that were labelled.^[17] Standard antibiotic ciprofloxacin (100 µg/mL) as positive control and DMSO as negative control were added and plates were allowed to diffuse at 4°C for 10 min. After diffusion, plates were incubated at 37°C for 48 hr. After incubation, the inhibitory zone was measured by using zone measuring scale.

Identification of Potent Bioactive compound producing actinobacterial isolates

The potent Actinobacterial isolate SBCP-1 was selected for molecular identification by 16S rRNA gene sequencing. To amplify the bacterial 16S rRNA gene, the universal primers 16S27F and 16S1492R were used.^[18] The ABI 3500XL Genetic Analyzer was used to sequence the amplified PCR product. Following sequencing, the trace files were exported as FASTA files. A database search was performed on the consensus sequence using the SILVA database v138^[19] using the BLAST tool.^[20] BLASTn was carried out against Silva 138.1 database using assembled fasta files and hits with highest similarity in the database. MEGA11 software was utilized to generate a consensus phylogram employing the maximum likelihood technique with 1000 iterations.^[21]

Column Chromatography for fractionation of bioactive compound

Crude Bioactive compounds obtained from n-butanol extract of *Streptomyces rochei* was proceeded for the column chromatography to collect the fractions. Silica gel-G with mesh size 100-120 was selected as the stationary phase while ethyl acetate: n-butanol was used as the mobile phase for elution of the fractions.^[15] The 5 mL elution fractions were carried out and fractions were collected followed by solvent evaporation.

Bioassay of fractions

The residues were dissolved in DMSO after evaporation and bioassay of each fraction was performed on Muller Hinton agar against MDR *E. coli* (PP854585), *E. coli* (PP854586) and *E. coli* (PP854587).^[22]

Thin Layer chromatography of *Streptomyces rochei* strain SC1 fraction

TLC was performed for the fraction which shows maximum antimicrobial activity. Using a ready to use TLC sheet as stationary phase and ethyl acetate: n-butanol: Water (40:40:20) as mobile phase for *Streptomyces rochei* extract.^[23]

Characterization of Bioactive Compound

The fraction with the maximum antimicrobial activity was characterized by metabolite screening with exact mass by UPLC-UV-MS technique using Agilent 6550 Q- ToF connected to Agilent 1260 Infinity II HPLC.^[24] For the chromatographic separation, an Agilent Eclipse XDB-C18 column (3X150 mm, 3.5 micron) was used, 15 µL was the volume of the sample injection. The mobile phase consisted of 0.1% formic acid in HPLC grade water (v/v) and 0.1% formic acid in HPLC grade acetonitrile (v/v), with a flow rate of 0.3 mL/min. In dual AJS ESI mode, the mass spectrophotometer was set up with these ESI source parameters: Sheath gas temperature: 350°C, capillary voltage: 3500V, nozzle voltage: 1000 V, drying gas: 8 l/min, nebulizer gas: 35 psi, and nebulizer gas temperature: 300°C. The scan range for the mass spectrophotometer spectra was 100-1700 m/z.

RESULTS

Isolation of actinobacteria from soil samples

A total of 17 Actinobacterial isolates were isolated on Starch casein agar from collected forest soil sample, as shown in Figure 1.

Antimicrobial Activity and Screening of Actinobacteria

Production and Extraction of Bioactive compound

The 6 Actinobacterial isolates SBCP-1, SBCP-2, SBCP-3, SBCP-4, SBCP-5 and SBCP-6 exhibited inhibitory activity against MDR *E. coli* in the primary screening were used for production of bioactive compounds in SCB. After production, fermented broth was extracted in ethyl acetate, n-butanol and chloroform.

Secondary screening of Potent Actinobacterial isolates

The n-butanol extract from Actinobacterial isolate SBCP-1 showed highest zone of inhibition against MDR *E. coli* (PP854585), *E. coli* (PP854586) and *E. coli* (PP854587) as shown in Figures 2-5.

Identification of Potent Bioactive compound producing actinobacterial isolates

On the basis of 16S rRNA gene sequence analysis Actinobacterial isolate SBCP-1 was identified as *Streptomyces rochei* and designated as *Streptomyces rochei* strain SC1 and it was deposited in GenBank under Accession No. PQ637672 and phylogenetic tree indicating the taxonomic position of *Streptomyces rochei* strain SC1 showed in Figure 6.

Column Chromatography for fractionation of bioactive compound

For purification of bioactive compound, the crude bioactive compounds of n-butanol extract from *Streptomyces rochei* strain SC1 was proceeded for the column chromatography and the fractions were collected.



Figure 1: Growth of pure Actinobacterial isolates from soil sample on SCA plate.

Bioassay of fractions

The residues were dissolved in DMSO after evaporation and bioassay of each fraction was performed on Muller Hinton agar against MDR *E. coli* (PP854585), *E. coli* (PP854586) and *E. coli* (PP854587) as shown in Table 1 and Figure 7.

Thin Layer chromatography of *Streptomyces rochei* fraction

The TLC of bioactive compound fraction which showed best activity obtained from *Streptomyces rochei* strain SC1 showed a single band spot which shows colour as shown in Figure 8.

Characterization of Bioactive Compound

The molecular structure of the compounds presents in the fraction which shows the most effective antibacterial activity has been identified using UPLC-UV-MS. The potent bioactive

compound namely 10-deoxymethynolide (C₁₇ H₂₈ O₄) having mass 296.1993 and Decylubiquinol (C₁₉ H₃₂ O₄) having mass 324.2306 from class Macrolide and Hydroquinone found in the fraction obtained from *Streptomyces rochei* strain SC1 as shown in Figures 9 and 10.

DISCUSSION

The *Escherichia coli* is an opportunistic pathogen, it can still infect immunocompromised individuals and cause diseases. Bloodstream infections, meningitis, pneumonia, sepsis, diarrhoea, and UTI's are all caused by certain strains of *E. coli*. Most of these diseases are treated with class β -lactam antibiotics, fluoroquinones, aminoglycosides, tetracycline, nitrofurantoin, sulphamide/trimethoprim, and chloramphenicol. The hospital acquired multidrug-resistant strain of *E. coli* that caused the UTI infection could not be adequately treated with commonly

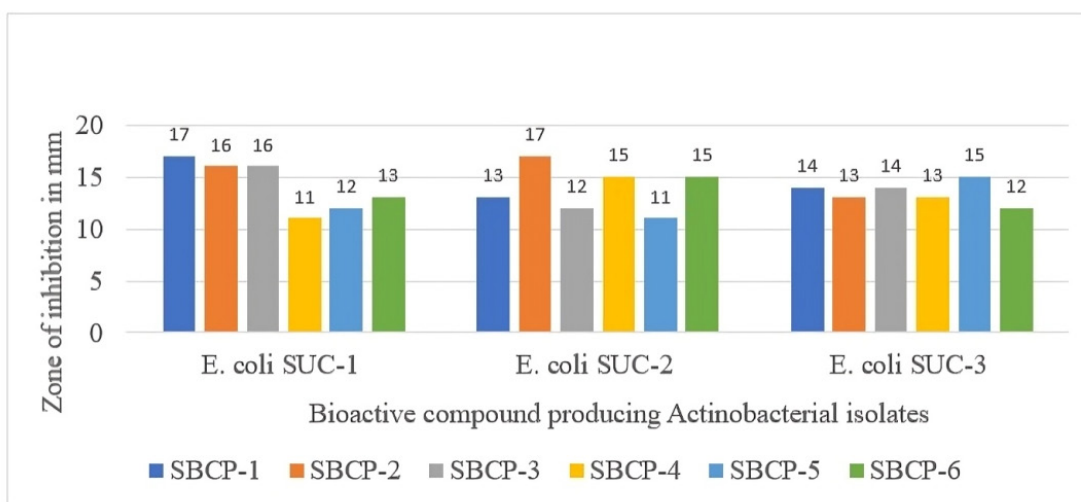


Figure 2: Secondary screening of ethyl acetate extract of Actinobacteria against MDR *E. coli* strains.

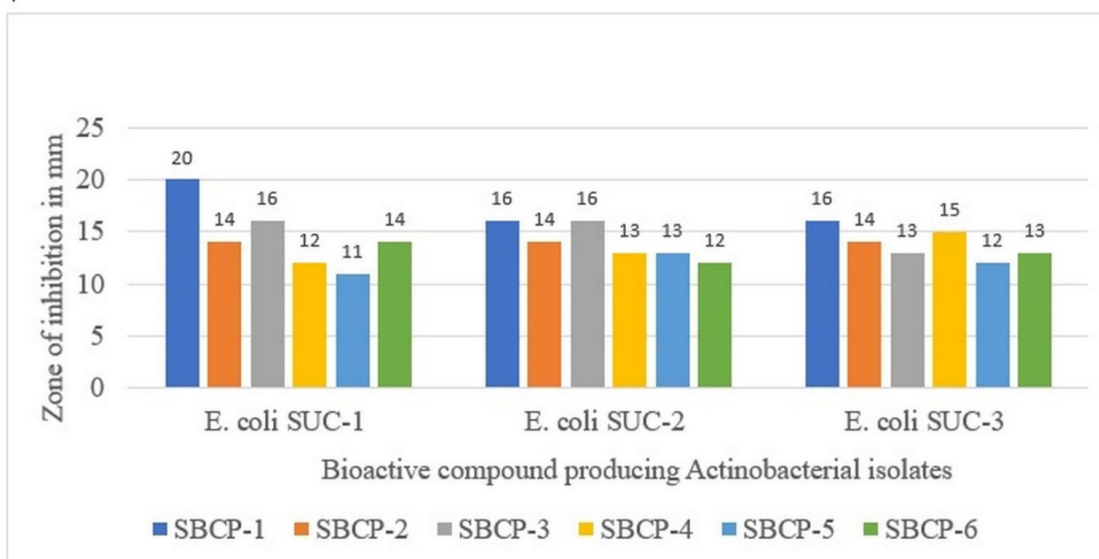


Figure 3: Secondary screening of n-butanol extract of Actinobacteria against MDR *E. coli* strains.

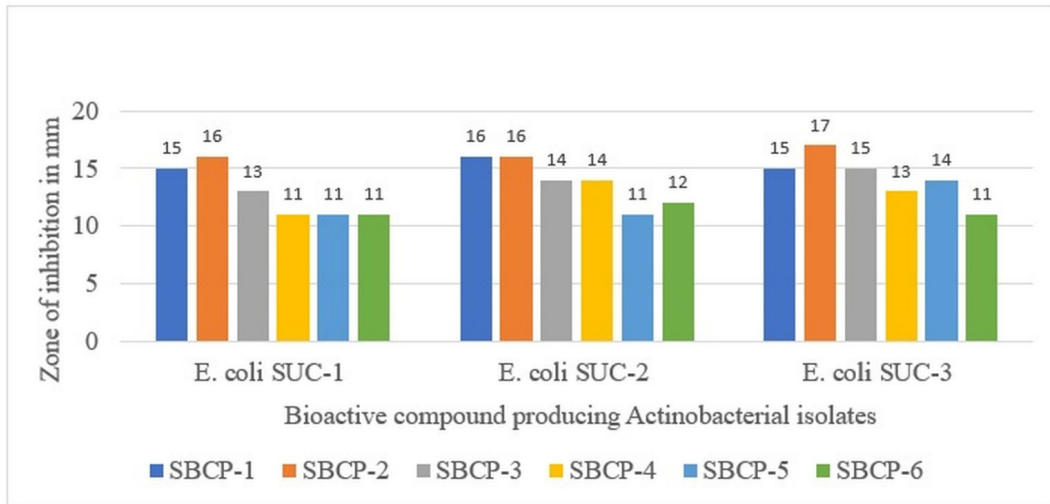


Figure 4: Secondary screening of chloroform extract of Actinobacteria against MDR *E. coli* strains.

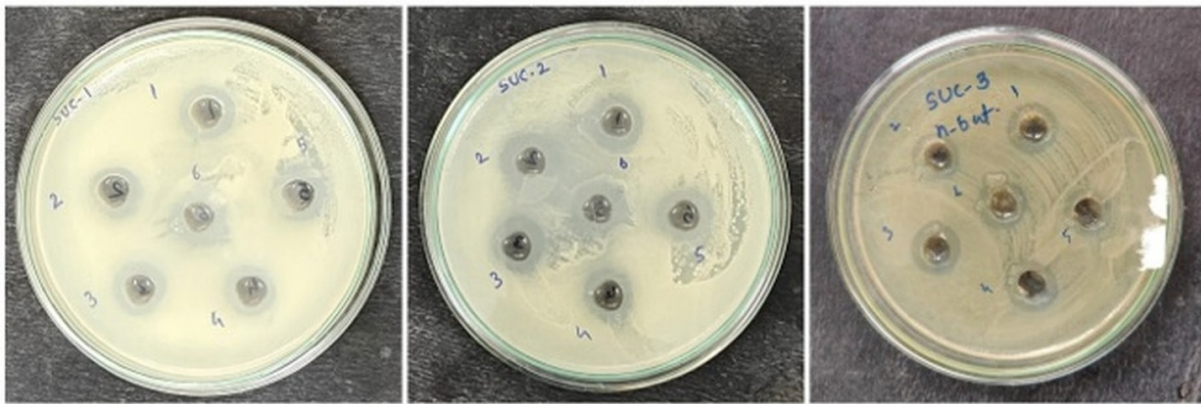


Figure 5: Secondary screening of n-butanol extract of Actinobacterial isolates SBCP-1 against MDR *E. coli* strains.

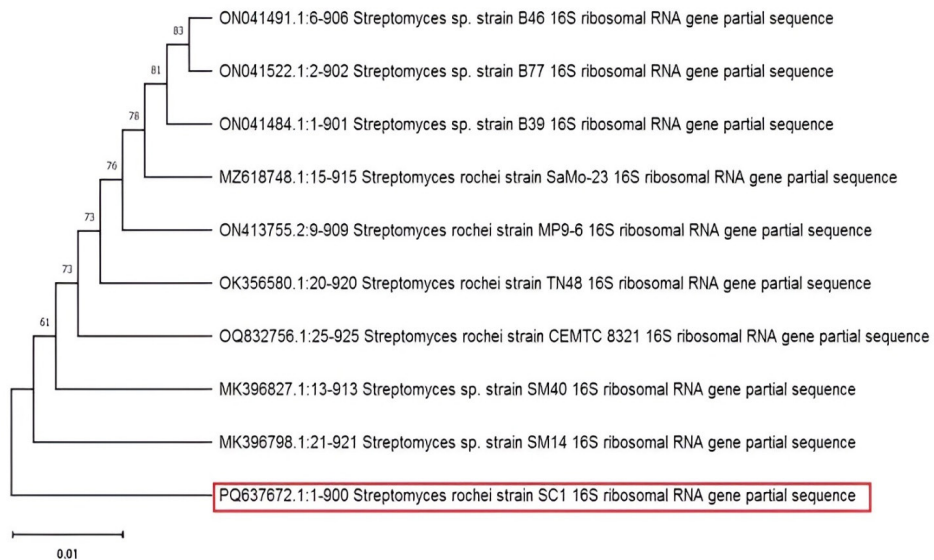


Figure 6: Phylogenetic tree indicating the taxonomic position of *Streptomyces rochei* strain SC1 (Actinobacterial isolate SBCP-1).

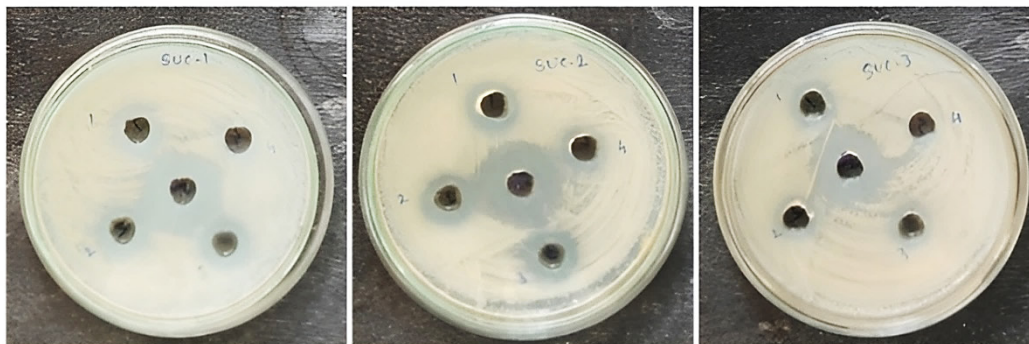


Figure 7: Bioassay of *Streptomyces rochei* fractions against MDR *E. coli*.



Figure 8: TLC of potent bioactive fraction obtained from *Streptomyces rochei* strain SC1.

available antibiotics in prescribed dosages. Discovering novel antibiotics from bacteria that thrive in extreme conditions is essential since these UTI infection causing bacteria need higher dosages of currently available antibiotics or combinations of antibiotics, which can have adverse effects.

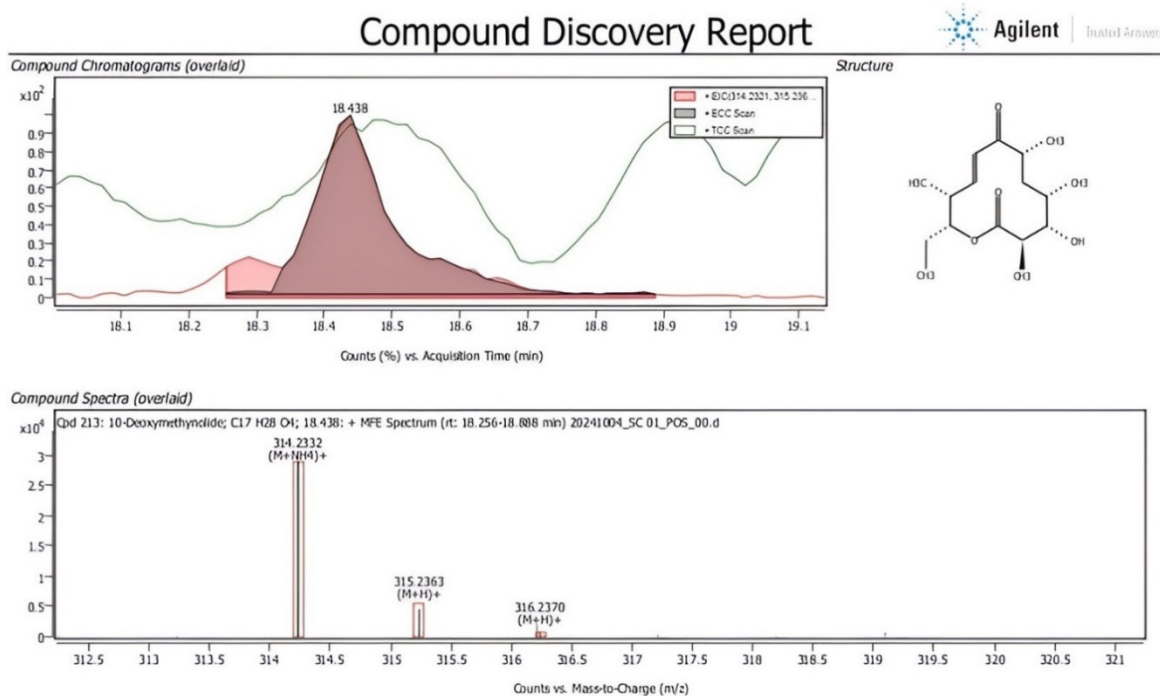
Using starch casein agar, the bioactive compound-producing *S. rochei* strain SC1 was isolated and identified from the forest soil. The identified *S. rochei* strain SC1 (PQ637672) showed maximum similarity with the genus *Streptomyces*. Similarly, six actinomycetes were isolated on SCA from Egyptian soil, using 16S rRNA gene sequencing the potent two actinomycetes isolates A2 and A6 were identified as *Streptomyces enissocaeilis* MT658130 and *Streptomyces atrovirens* MT658195 respectively.^[25] *Streptomyces fimbriatus* AC31 was identified by using 16S rRNA sequencing from the Saharan soil of El Atteuf; Ghardaïa.^[26] Ethyl acetate, n-hexane, dichloromethane, chloroform, and methanol have all been reported to be effective in the extraction of *S. rochei* secondary metabolites. The specific solvent used may have an impact on the secondary metabolites that are extracted and the purity contained in the final extract. n-butanol has effectively extracted the bioactive secondary metabolite that exhibits

inhibitory activity against MDR *E. coli* from the fermentation broth of *S. rochei*. However, ethyl acetate and chloroform showed lower anti-MDR *E. coli* activity. They extracted secondary metabolites using n-butanol from fermented broth of *Streptomyces clavuligerus* isolated from KSA.^[27] Similarly, the antibacterial secondary metabolites from marine *Streptomyces* sp. VITBRK2 were also extracted using ethyl acetate.^[28] Likewise, ethyl acetate used to extract secondary metabolites produced by *S. rochei*.^[29]

A wide variety of compounds are present in the organic solvent extract of the bioactive secondary metabolite that is extracted from microorganisms. In order to determine fraction-guided antibacterial activity, each of the parts are frequently fractionated using HPLC and column chromatography. Three separate fractions were eluted from the *S. rochei* n-butanol extract using column chromatography. Maximum antibacterial activity against MDR *E. coli* was demonstrated by the third fraction. The bioactive compounds produced by *Streptomyces* sp. CMSTHHAL-4 was purified using column chromatography, one fraction out of 23 fractions showed maximum antibacterial activity against *S. aureus*, *K. pneumoniae*, *E. coli* and *P. aeruginosa*.^[30] Using silica gel column chromatography purified the antimicrobial

Table 1: Bioassay of *Streptomyces rochei* fractions against MDR *E. coli*.

Sl. No.	Compound	<i>E. coli</i> SUC-1	<i>E. coli</i> SUC-2	<i>E. coli</i> SUC-3
Zone of inhibition in mm				
1.	Fraction-1	16	15	14
2.	Fraction-2	16	16	13
3.	Fraction-3	17	17	14
4.	DMSO	0	0	0
5.	Ciprofloxacin (Positive control)	24	25	20

**Figure 9:** Deoxymethynolide identified in *Streptomyces rochei* fraction by UPLC-UV-MS.

compound having antimicrobial activity against MRSA and *F. oxysporum* was found in eight fractions eluted with chloroform: ethyl acetate (60:40, v/v).^[31] Active fraction of TLC was subjected to column chromatography, a total of 30 different fractions were obtained, the largest zone of inhibition was observed against *K. pneumoniae*, *E. coli* and *P. aeruginosa* in the 21st fraction among other fractions.^[32]

Determination of compounds structure with biological activity is crucial to understand their properties, modes of action, and applications. The pure fraction of bioactive compounds is structurally characterized using NMR, MS, IR spectroscopy, HPLC and UPLC-UV-MS. These techniques combine mass analysis with spectroscopy. We identified compounds from *S. rochei* that have anti-MDR *E. coli* activity. These compounds include 10-deoxymethynolide (C₁₇H₂₈O₄), which has a mass of 296.1993, and Decylubiquinol (C₁₉H₃₂O₄), which has a mass of 324.2306 and belongs to the class Macrolide and Hydroquinone, respectively. The structure of the compounds has been explained

using the UPLC-UV-MS technique. Gas chromatography, mass spectrometer analysis, and FTIR spectroscopy used to characterize the bioactive secondary metabolites produced by *Streptomyces* sp. CMSTAAHL-4. They found five bioactive compounds that had bacterial activity against *S. aureus*, *K. pneumoniae*, *E. coli*, *P. aeruginosa*, and *S. typhi*.^[30] Using UV-VIS spectrometry, infrared spectroscopy, and GC-MS techniques they characterized bioactive compounds produced by *Streptomyces* sp. The GC-MS revealed that *Streptomyces* sp. SUI, *Streptomyces* sp. SW72IV, and *Streptomyces* sp. SW72VII, were the main producers of elaidic acid isopropyl ester, Octadec-9-enoic acid, and 2, 3-dihydroxyl elaidate, respectively. These strains demonstrated antimicrobial activity against *P. aeruginosa* ATCC 9077, *S. aureus* ATCC 700699, *C. albicans*, and *A. favus*.^[33] Also, the LC-ESI-MS/MS analysis used to identify bioactive compounds from *Streptomyces rochei* with antimicrobial abilities. They discovered 21 new unique secondary metabolites with notable antibacterial activity against *B. cereus*, *S. aureus*, and *S. typhimurium*.^[34] The UPLC-UV-MS

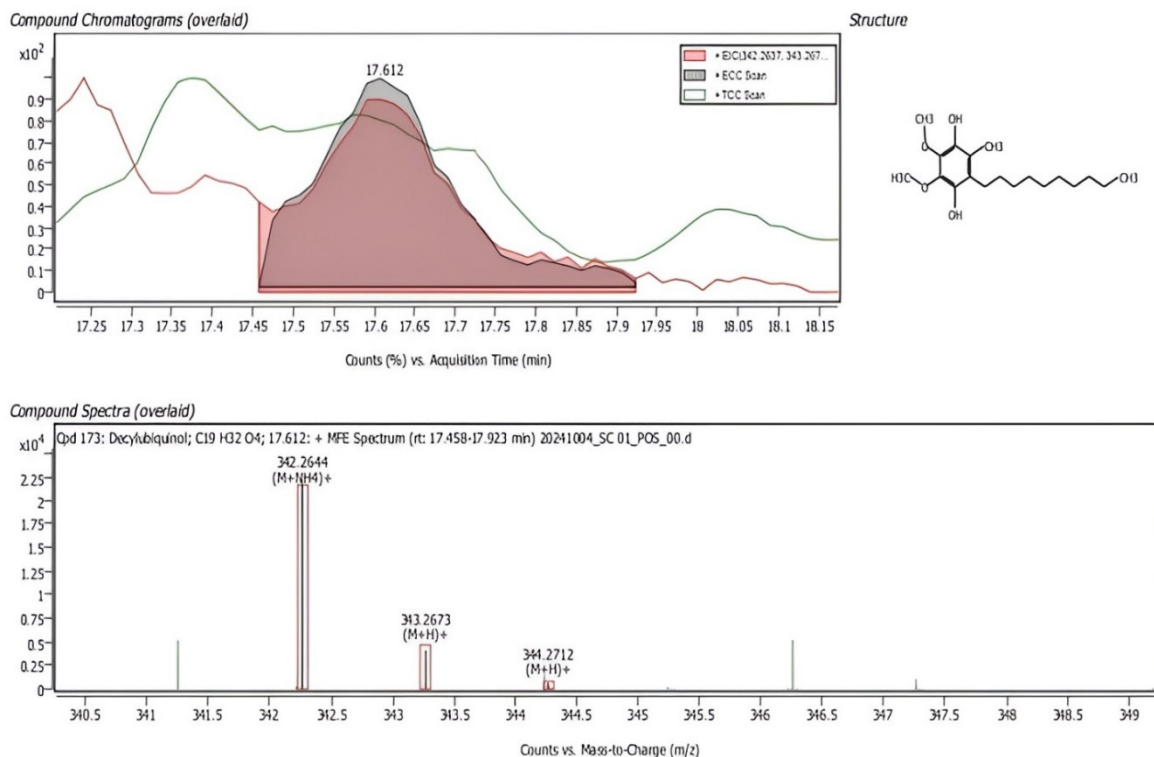


Figure 10: Decylubiquinol identified in *Streptomyces rochei* fraction by UPLC-UV-MS.

combines the separation capacity of UPLC with the analytical abilities of UV-VIS and MS to evaluate complicated structure of bioactive molecules with outstanding sensitivity and specificity.

CONCLUSION

Streptomyces rochei strain SC1 was isolated from forest soil have ability to produce bioactive compounds namely 10-deoxymethynolide (C₁₇ H₂₈ O₄) and Decylubiquinol (C₁₉ H₃₂ O₄) belongs to the class Macrolide and Hydroquinone, respectively. These compounds had showed growth inhibitory activity against MDR *E. coli*.

ACKNOWLEDGEMENT

Author Sanjay Chavan thankful to UGC, New Delhi and Bhagvat Lad thankful to MAHAJYOTI, Nagpur for providing research fellowship.

ABBREVIATIONS

AJS ESI: Agilent Jet Stream Electrospray Ionization; **BLAST:** Basic Local Alignment Search Tool; **C. albicans:** *Candida albicans*; **DMSO:** Dimethyl sulfoxide; **ESI:** Electrospray Ionization; **FTIR:** Fourier-Transform Infrared Spectroscopy; **GC-MS:** Gas Chromatography-Mass Spectrometry; **HPLC:** High-Performance Liquid Chromatography; **KSA:** Kingdom of Saudi Arabia; **LC-ESI-MS/MS:** Liquid Chromatography-Electrospray Ionization-Tandem Mass Spectrometry; **MDR:** Multi-Drug Resistant; **MEGA11:** Molecular Evolutionary

Genetics Analysis Version 11; **MHA:** Muller Hinton Agar; **MRSA:** Methicillin-Resistant *Staphylococcus aureus*; **MS:** Mass Spectrometry; **NMR:** Nuclear Magnetic Resonance; **PCR:** Polymerase Chain Reaction; **SCA:** Starch Casein Agar; **SCB:** Starch Casein Broth; **TLC:** Thin Layer Chromatography; **ToF:** Time-of-Flight; **UPLC-UV-MS:** Ultra-Performance Liquid Chromatography-Ultra-Violet-Mass Spectrometry; **UTI:** Urinary Tract Infection; **UV-VIS:** Ultraviolet-Visible.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

- Elsilk, S. E., Khalil, M. A., Aboshady, T. A., Alsalmi, F. A., and Ali, S. S. *Streptomyces rochei* MS-37 as a Novel Marine Actinobacterium for Green Biosynthesis of Silver Nanoparticles and their Biomedical Applications. *Molecules* (Basel, Switzerland), 2022;27(21):7296.
- Arakawa, K., Sugino, F., Kodama, K., Ishii, T., and Kinashi, H. Cyclization mechanism for the synthesis of macrocyclic antibiotic lankacidin in *Streptomyces rochei*. *Chemistry and biology*, 2005;12(2):249-56.
- Anukool, U., Gaze, W. H., and Wellington, E. M. *In situ* monitoring of streptothricin production by *Streptomyces rochei* F20 in soil and rhizosphere. *Applied and environmental microbiology*, 2004;70(9):5222-8.
- Ashraf, N., Bechthold, A., Anwar, M. A., Ghauri, M. A., Anjum, M. S., Khan, A. N., et al. Production of a broad-spectrum streptothricin like antibiotic from halotolerant *Streptomyces fimbriatus* isolate G1 associated with marine sediments. *Folia microbiologica*, 2021;66(4):639-49.
- Orole, O. O., Gambo, S. M., and Fadayomi, V. S. Characteristics of virulence factors and prevalence of virulence markers in resistant *Escherichia coli* from patients with gut and urinary infections in Lafia, Nigeria. *Microbiology insights*, 2022;15:11786361221106993.
- Zhou, Y., Zhou, Z., Zheng, L., Gong, Z., Li, Y., Jin, Y., and Chi, M. Urinary tract infections caused by uropathogenic *Escherichia coli*: mechanisms of infection and treatment options. *International journal of molecular sciences*, 2023;24(13):10537.

7. Kot, B. Antibiotic resistance among uropathogenic *Escherichia coli*. Polish journal of microbiology, 2019;68(4):403.
8. Arbab, S., Ullah, H., Wang, W., and Zhang, J. Antimicrobial drug resistance against *Escherichia coli* and its harmful effect on animal health. Veterinary Medicine and Science, 2022;8(4):1780-6.
9. Jagannathan, S. V., Manemann, E. M., Rowe, S. E., Callender, M. C., and Soto, W. Marine actinomycetes, new sources of biotechnological products. Marine Drugs, 2021;19(7):365.
10. Reddy, N. G., Ramakrishna, D. P. N., and Rajagopal, S. V. Optimization of culture conditions of *Streptomyces rochei* (MTCC 10109) for the production of antimicrobial metabolites. Egyptian Journal of Biology, 2011;13:21-29.
11. Waksman, Selman Abraham. "The Actinomycetes. Vol. II. Classification, identification and descriptions of genera and species." (1961): ix+363.
12. Meenakshi, S., et al. "Actinomycetes: Isolation, Cultivation and its Active Biomolecules." Journal of Pure and Applied Microbiology, 2014;18:1.
13. Azam, Mohd, Rashi Srivastava, and Tanzeel Ahmed. "Isolation and Characterization of Bacteriocin Producing *Levilactobacillus Brevis* strain ABR11NW-K from Buffalo Dung." J. Pure Appl. Microbiol, 2024;18:2137-46.
14. Rajivgandhi, Govindan, et al. "Molecular characterization and antibacterial effect of endophytic actinomycetes *Nocardioopsis* sp. GRG1 (KT235640) from brown algae against MDR strains of uropathogens." Bioactive materials 1.2,2016;140-50.
15. Chanthasena, P., Hua, Y., Rosyidah, A., Pathom-Aree, W., Limphirat, W., and Nantapong, N. Isolation and Identification of Bioactive Compounds from *Streptomyces actinomycinicus* PJ85 and their *in vitro* Antimicrobial Activities against Methicillin-Resistant *Staphylococcus aureus*. Antibiotics (Basel, Switzerland), 2022;11(12):1797.
16. Nisha, S. J., Uma, G., Sathishkumar, R., Prakash, V. S. G., Isaac, R., and Citarasu, T. Optimization and characterization of bioactive secondary metabolites from *Streptomyces* sp. CMSTAAHL-4 isolated from mangrove sediment. BMC microbiology, 2025;25(1):57.
17. Warsito, M. F., Nasution, N. E., Merthaniasih, N. M., Poernomo, A. T., Fairuz, D., and Hanifah, A. Antibacterial Activity of Butanol Extract from Cell Free Fermentation Broth of *Streptomyces* spp. Isolated from Vegetable Plantation Soil. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 2017;8(1):1921-7.
18. Weisburg, W G, S M Barns, D A Pelletier, and D J Lane. "16S Ribosomal DNA Amplification for Phylogenetic Study." Journal of Bacteriology, 1991;173(2):697-703.
19. Quast, Christian, Elmar Pruesse, Pelin Yilmaz, Jan Gerken, Timmy Schweer, Pablo Yarza, Jörg Peplies, and Frank Oliver Glöckner. "The SILVA Ribosomal RNA Gene Database Project: Improved Data Processing and Web-Based Tools." Nucleic Acids Research, 2021;41(D1): D590-96.
20. Altschul, Stephen F., Warren Gish, Webb Miller, Eugene W. Myers, et al. "Basic Local Alignment Search Tool." Journal of Molecular Biology, 1990;215(3):403-10.
21. Tamura, Koichiro, Glen Stecher, and Sudhir Kumar. "MEGA11: Molecular Evolutionary Genetics Analysis Version 11." Edited by Fabia Ursula Battistuzzi. Molecular Biology and Evolution, 2021;38(7):3022-27.
22. Kawai, S. J., Asamizu, S., Suzuki, H., Onaka, H., Arakawa, Y., Kimura, K., et al. Griseolutein T from *Streptomyces seoulensis*, newly identified via combined-culture with *Tsakumurella pulmonis*, as an efficacious therapeutic agent against multidrug-resistant bacteria. The Journal of Antibiotics, 2025; 1-10.
23. Holkar, S., Begde, D., Nashikkar, N., Kadam, T., and Upadhyay, A. Rhodomycin analogues from *Streptomyces purpurascens*: isolation, characterization and biological activities. Springerplus, 2013;2(1):93.
24. Jia, C., Ma, X., Jiang, Y., Cheng, S., Yue, S., and Su, J. Analysis of Secondary Metabolite Synthesis Potential of *Streptomyces fradiae* sf106 Based on the Whole Genome and Non-Target Metabolomics and Exploration of the Biosynthesis of Tylosin. Fermentation, 2023;9(10):866.
25. Daigham, G. E., and Mahfouz, A. Y. Isolation, characterization, and screening of actinomycetes producing bioactive compounds from Egyptian soil. Egyptian Pharmaceutical Journal, 2020;19(4):381-90.
26. Khirennas, O., Mokrani, S., Behira, B., Bouras, N., Driche, E. H., and Moumen, O. Isolation, identification and screening of saharan actinomycete strain *Streptomyces fimbriatus* AC31 endowed with antimicrobial activity. International Journal of Molecular and Cellular Medicine, 2023;12(1):51.
27. Atta, H. M., and Yassen, A. M. Phylogenetic characterization, fermentation and biological activities of an antibiotic producing *Streptomyces clavuligerus* isolated from KSA. Int. J. Curr. Microbiol. App. Sci, 2014;3(12):519-34.
28. Rajan, B. M., and Kannabiran, K. Extraction and Identification of Antibacterial Secondary Metabolites from Marine *Streptomyces* sp. VITBRK2. International journal of molecular and cellular medicine, 2014;3(3):130-7.
29. Patel, P., Patel, G., and Mehta, P. Extraction and Molecular Characterization of Antimicrobial Metabolites from *Streptomyces rochei* against Bacterial Leaf Blight of Cotton Caused by *Pantoea* sp. Asian Journal of Biological and Life Sciences, 2020;2(2):159.
30. Nisha, S. J., Uma, G., Sathishkumar, R., Prakash, V. S. G., Isaac, R., and Citarasu, T. Optimization and characterization of bioactive secondary metabolites from *Streptomyces* sp. CMSTAAHL-4 isolated from mangrove sediment. BMC microbiology, 2025;25(1):57.
31. Devi, S., Sharma, M., and Manhas, R. K. Purification and biological analysis of antimicrobial compound produced by an endophytic *Streptomyces* sp. Scientific report, 2023;13(1):15248. <https://doi.org/10.1038/s41598-023-41296-x>
32. Dhanasekaran Kokila1, Venkatapathi Bhuvaneshwari, Manickam Ramesh, Natarajan Ranjani and Ranganathan Kannan Optimization, Chromatography-based Purification and characterization of novel Antibacterial compound 4-formyl-2-hydroxy bicyclo [4.1.0] heptane-7-carboxylicacid produced by *Streptomyces rochei* (OM746935). Biological Forum - An International Journal, 2023;15(5):1352-61.
33. Adeyemo, O. M., Ja'afaru, M. I., and Adams, F. V. Isolation, characterization, antimicrobial and other bioactivity profiles of three *Streptomyces* strains isolated from Lake Gerio, Yola, Adamawa State, Nigeria. Bulletin of the National Research Centre, 2021;45(1):147.
34. Ali, A. M., Makboul, H. E., and Moselhy, M. A. LC-ESI-MS/MS Analysis of Bioactive Metabolites from *Streptomyces rochei* with Antimicrobial, Antioxidant, and Cytotoxic Properties. Egyptian Journal of Chemistry, 2024;67(13):1947-56.

Cite this article: Chavan S, Lad B, Kadam T. Production and Characterization of Antimicrobial Metabolites from *Streptomyces rochei* Strain SC1 against Multi-Drug-Resistant *Escherichia coli*. Asian J Biol Life Sci. 2025;14(3):657-65.