frontiers | Frontiers in Microbiology

TYPE Original Research
PUBLISHED 17 February 2023
DOI 10.3389/fmicb.2023.1096826

OPEN ACCESS

EDITED BY
Sumit Kumar,
Amity University,
India

REVIEWED BY
Amr Shehabeldine,
Al-Azhar University,
Egypt
Salma Mukhtar,
Connecticut Agricultural Experiment Station,
United States

*CORRESPONDENCE
Manjula Ishwara Kalyani
✉ manjuganesh7176@gmail.com
Muntazir Mushtaq
✉ muntazirhuda@gmail.com

SPECIALTY SECTION
This article was submitted to Extreme Microbiology, a section of the journal Frontiers in Microbiology

RECEIVED 12 November 2022
ACCEPTED 26 January 2023
PUBLISHED 17 February 2023

CITATION
Karthik Y, Ishwara Kalyani M, Krishnappa S, Devappa R, Anjali Goud C, Ramakrishna K, Wani MA, Alkafafy M, Hussen Abduljabbar M, Alswat AS, Sayed SM and Mushtaq M (2023) Antiproliferative activity of antimicrobial peptides and bioactive compounds from the mangrove *Glutamicibacter mysorens*. *Front. Microbiol.* 14:1096826. doi: 10.3389/fmicb.2023.1096826

Antiproliferative activity of antimicrobial peptides and bioactive compounds from the mangrove *Glutamicibacter mysorens*

Yalpi Karthik[1], Manjula Ishwara Kalyani[1]*, Srinivasa Krishnappa[2], Ramakrishna Devappa[3], Chengeshpur Anjali Goud[4], Krishnaveni Ramakrishna[5], Muneeb Ahmad Wani[6], Mohamed Alkafafy[7], Maram Hussen Abduljabbar[8], Amal S. Alswat[9], Samy M. Sayed[10] and Muntazir Mushtaq[11,12]*

[1]Department of Studies and Research in Microbiology, Mangalore University, Mangalore, Karnataka, India, [2]Department of Studies and Research in Biochemistry, Mangalore University, Mangalore, Karnataka, India, [3]Dr. C.D Sagar Centre for Life Sciences, Biotechnology Department, Dayananda Sagar College of Engineering, Dayananda Sagar Institutions, Bengaluru, India, [4]Department of Plant Biotechnology, School of Agricultural Sciences, Malla Reddy University, Hyderabad, India, [5]Department of Studies and Research in Microbiology, Vijayanagara Sri Krishnadevaraya University, Ballari, Karnataka, India, [6]Division of Floriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Srinagar, Jammu and Kashmir, India, [7]Department of Cytology and Histology, Faculty of Veterinary Medicine, University of Sadat City, Sadat City, Egypt, [8]Department of Pharmacology and Toxicology, College of Pharmacy, Taif University, Taif, Saudi Arabia, [9]Department of Biotechnology, College of Science, Taif University, Taif, Saudi Arabia, [10]Department of Economic Entomology and Pesticides, Faculty of Agriculture, Cairo University, Giza, Egypt, [11]ICAR-National Bureau of Plant Genetic Resources, Division of Germplasm Evaluation, New Delhi, India, [12]MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management, Bajhol, Himachal Pradesh, India

The *Glutamicibacter* group of microbes is known for antibiotic and enzyme production. Antibiotics and enzymes produced by them are important in the control, protection, and treatment of chronic human diseases. In this study, the *Glutamicibacter mysorens* (*G. mysorens*) strain MW647910.1 was isolated from mangrove soil in the Mangalore region of India. After optimization of growth conditions for *G. mysorens* on starch casein agar media, the micromorphology of *G. mysorens* was found to be spirally coiled spore chain, each spore visualized as an elongated cylindrical hairy appearance with curved edges visualized through Field Emission Scanning Electron Microscopy (FESEM) analysis. The culture phenotype with filamentous mycelia, brown pigmentation, and ash–colored spore production was observed. The intracellular extract of *G. mysorens* characterized through GCMS analysis detected bioactive compounds reported for pharmacological applications. The majority of bioactive compounds identified in intracellular extract when compared to the NIST library revealed molecular weight ranging below 1kgmole^{-1}. The Sephadex G-10 could result in 10.66 fold purification and eluted peak protein fraction showed significant anticancer activity on the prostate cancer cell line. Liquid Chromatography–Mass Spectrometry (LC–MS) analysis revealed Kinetin-9-ribose and Embinin with a molecular weight below 1kDa. This study showed small molecular weight bioactive compounds produced from microbial origin possess dual roles, acting as antimicrobial peptides (AMPs) and anticancer peptides (ACPs). Hence, the bioactive compounds produced from microbial origin are a promising source of future therapeutics.

KEYWORDS

anticancer, chromatography, FESEM, *Glutamicibacter mysorens*, mangrove soil, microbial peptides

Introduction

The environmental conditions in a particular ecosystem play an important role in determining biodiversity composition. High tides, hypersaline water, significant temperature fluctuations, and optimal flora and fauna diversity are just a few of the distinctive environmental characteristics of the mangrove ecosystem (Karthik et al., 2020). Microbes can better adapt to any extreme environment in these vulnerable situations. The isolation of bioactive chemicals will be greatly aided by this habitat (Alongi, 2015).

Actinomyces word derived from the words "atkis" which means "a ray" and "mykes" which means "fungi" are filamentous, Gram–positive bacteria distinguished by different coloration and spore production at maturity (Chater, 2006). *Actinomyces* share the characteristics of bacteria and fungi. The *Actinomyces* group's genetic and environmental flexibility facilitates the development of worthwhile bioactive substances. *Actinomyces* contribute more in enzyme production to pharmacological industries for the treatment, and prevention of various ailments (Chater, 2013).

The pharmaceutical industry is constantly looking for drugs with innovative structures and new modes of action as a result of the rise in antibiotic resistance. There are still many environmental niches to investigate as potential sources of antibiotics (Karthik and Kalyani, 2021, 2022). One such *Actinomyces* group *Glutamicibacter* genus is broadly utilized in the control, treatment, and prevention of diseases through the production of bioactive compounds, widely used as antibiotics (Phuong and Diep, 2020), anti-tumor, anti-tubercular (Khusro et al., 2020), anti-helminthic, anti-diabetic, anti-oxidant from an exo-polysaccharide (Xiong et al., 2020; Fukuda and Kono, 2021; Hidri et al., 2022), anti-angiogenic, growth hormones (Qin et al., 2018; Hidri et al., 2022), immuno-suppressors, neuritogenic (Tang et al., 2021), anti-inflammatory (Hui et al., 2021), anti-algal (Agamennone et al., 2018), anti-fungal with enzymatic source (Mihooliya et al., 2017; Asif et al., 2020), anti-proliferative (Baig et al., 2021), anti-parasitic, anti-malarial, anti-viral, anti-bacterial and many more biological applications (Nishioka and Katayama, 1978; Renner et al., 1999; Fernebro, 2011; Janardhan et al., 2014; Desouky et al., 2015; Abd-Elnaby et al., 2016).

The various species of genus *Glutamicibacter* shown huge biological importance as detailed above. Whereas *G. creatinolyticus* shown resistance to antibiotics as well as heavy metals (copper, arsenic, cadmium, cobalt, zinc, and chromium; Santos et al., 2020). The *G. arilaitensis* produced pink colored pigment and coprophorphyrin binds zinc and regulates in cheese rinds (Cleary et al., 2018). Another *Gluamicibacter sps.* Possessing genes that regulates the growth of plant under saline conditions, cold adaptation, efficient degradation and chitinase enzyme producing genes which help in control the growth of pathogenic bacteria (Borker et al., 2021; Fu et al., 2021). While *G. nicotianae* involved in heavy metals degradation (Wang et al., 2021). The *G. mishrai* and *halophytocola* isolated from Andaman sea sample. Genes involved in cell wall biogenesis, replication, recombination, repair mechanism and amino acid metabolism along possess important role in physiology and behavior of insects (Qin et al., 2018; Das et al., 2020; Wang W, et al., 2022).

Antimicrobial peptides (AMPs) are peptides with antimicrobial properties. In multicellular organisms, these positively charged host defense molecules, or AMPs, serve as the initial line of protection. Many AMP's from both prokaryotes and eukaryotes have been categorized (Brandenburg et al., 2012; Desriac et al., 2013). Several genera of AMP's -producing microorganisms have been discovered, including bacteriocins produced by *Leuconostoc gelidum*, *Enterococcus faecium*, and other species (Juturu and Wu, 2018; Khodaei and Sh, 2018). Microcins A and B, antimicrobial bacteriocins derived from *Streptomyces pluripotens*, have been shown to be effective against *Escherichia coli, Salmonella typhimurium, Staphylococcus aureus,* and *Listeria monocytogenes* (Collin and Maxwell, 2019; Kurnianto et al., 2021).These AMPs have been found to be effective in the treatment of a broad range of ailments (Sugrue et al., 2019; Karthik et al., 2020; Khadayat et al., 2020; Zhang et al., 2020). AMP's are peptides derived from microbes that exhibit antimicrobial activity. AMPs have been shown to target cell walls or cell membranes, permitting them to penetrate cells and affect vital components while inhibiting growth (Desriac et al., 2013; Wang et al., 2020). As a result of their target-specific activity against resistant microbial species, AMPs are thought to be anti–microbial compounds.

Peptides with selective action and non-selective activity, i.e., those that have activity against bacteria, cancer cells, and healthy cells, can be categorized as having antitumor activity in Hoskin and Ramamoorthy's investigations (Hoskin and Ramamoorthy, 2008).The peptides have antibacterial and anticancer properties, but not against normal cells. Cecropins, buforins, and magainins, among other peptides, have demonstrated anticancer effects without harming normal eukaryotic cells (Cruciani et al., 1991; Cho et al., 2009). These studies go into great detail and provide a compelling case for the fact that many peptides have biological activity in a variety of dimensions and properties and can possess dual activity as AMPs and ACPs. Therefore, we are searching for mangrove soil *Actinomyces* in the Mangalore region to isolate and characterize bioactive peptides that can function as both AMPs and ACPs.

In our previous study, we reported the detailed procedures for isolation, microscopic and macroscopic characters, identified as *Glutamicibacter mysorens* with GenBank accession number MW647910.1, the intracellular protein; extraction, estimation, along with their potential antimicrobial activity was observed against test pathogens *Salmonella typhimurium* (ATCC23564), *Staphylococcus aureus* (ATCC6538P),*Bacillus cereus* (ATCC10876), *Proteus vulgaris* (ATCC13315), and *Pseudomonas aeruginosa* (ATCC9027) cultures. The protein was characterized through LCMS and SDS PAGE techniques and small peptides were detected (Karthik and Kalyani, 2021).

In this study, the optimization of suitable growth media for *G. mysorens* and its micromorphology were analyzed using FESEM. The isolation of intracellular extract of *G. mysorens* was characterized through GCMS and LCMS. These GCMS studies revealed a large number of small bioactive compounds that possess significant biological activities are discussed. Whereas the LCMS studies resulted in the detection of low molecular weight Kinetin-9-ribose and Embinin showed significant anti-tumor potential against PC3 cell line in comparison to standard cisplatin drug.

Materials and methods

Mangrove soil collection

Soil samples were collected from Mangroves soil in Mangalore, Dakshina Kannada. Jeppinamogaru (JPMU) is located at 12°50′31.4"N 74°51′36.4"E. At the collecting site, the soil was brown with a powdery

texture, and environmental parameters; the temperature of 21°C and pH of 7.2 was recorded. The collected samples were shifted to the Molecular Research Laboratory (MRL), Department of Microbiology, Jnana Kaveri, Mangalore University, India, in aseptic containers. To prevent fungal and bacterial growth, the soil sample was pre-heated for 2 h at 60°C prior to serial dilution and isolation (Mohan et al., 2013; Sridevi et al., 2015; Sapkota et al., 2020).

Cultural characteristics

The isolated *G. mysorens* strain was subjected to FESEM analysis at different objectives distances; spore structure (1 and 2 µm) mycelial structure (10 and 20 µm) to visualize the complete micromorphological structures. The sequencing and identification of *G. mysorens* are reported by Karthik and Kalyani (2021).

Intracellular extract

The *G. mysorens* strain was grown in SCN broth for 7 days at 30 ± 2°C with continuous shaking at 100 rpm. Centrifugation at 7000 rpm for 8 min separated the cultured biomass cells, which were then washed twice using phosphate-buffered saline devoid of Mg^{2+} and Ca^{2+} and centrifuged again. The cells were then re-suspended in 10 ml of chilled acetone for 5 min before being centrifuged at 7,000 rpm for 8 min. The intracellular extract was incubated for 2 min with 1.0 ml of 1% SDS after the traces of acetone was removed with a nitrogen stream (Bhaduri and Demchick, 1983). This intracellular extract was characterized using spectrometric (LCMS, GCMS) tools along with a comparison to the NIST library.

Gas chromatography-mass spectroscopic analysis

The following equipment was assessed for the GC–MS studies of *G. mysorens* intracellular extract: a PerkinElmer Clarus 680 Gas Chromatograph and a PerkinElmer Clarus SQ 8C Mass Spectrometer. A PerkinElmer Elite-5MS standard column with dimensions of 30 m long x 0.250 mm inner diameter x 1 micron (60–350°C) is utilized in the equipment. With an equivalence ratio of 10:1, the injected volume of 2 µl was completely run for 26.6 min. Helium is used as the carrier gas, with a flow rate of 2 ml/min. The source temperature was set to 230 degrees Celsius, and the inlet temperature was set to 250 degrees Celsius. The oven temperature was initially set to 80°C with a hold time of 2.0 min; ramp1 was set to 10.0 /min to 150°C with a hold time of 1.0 min; and ramp2 was set to 15.0 /min to 250°C with a hold time of 10.0 min. The components were identified by comparing them to those contained in the NIST computer library, which was linked to the GC–MS apparatus, and the results were published.

Gel filtration

The microbial proteins were purified using SephadexG-10. For 5 h, the Sephadex G-10 was allowed to swell in excess of dH_2O in a boiling water bath. After decanting the gel to remove fines, it was equilibrated with 0.05 M sodium phosphate buffer, pH 7.0. Under gravity, the gel was packed into a 1.0 cm × 110.0 cm column. At a flow rate of 10 ml/h, the column was standardized with two-bed volumes of phosphate buffer of concentration 0.05 M, pH 7.0. The 20 mg of isolate protein sample was loaded onto the gel, eluted with 0.05 M sodium phosphate buffer, pH 7.0, and 2.0 ml fractions were collected and further analyzed (Bharadwaj et al., 2018).

Liquid chromatography-mass spectrophotometer

The Sephadex G-10 peak fraction was analyzed using LC–MS, model Synapt G2, an analytical chemistry technique that combines the physical separation capabilities of liquid chromatography with mobile phases A: 0.1% Formic acid in Water and mobile phase B: 0.1% Formic acid in Acetonitrile with the mass analysis capabilities of mass spectrometry (MS) an Agilent 1100 LC system with a vacuum degasser, A BEH C18, 50 mm × 1.0 mm, 1.7 µm C18 column (Waters, United States) was used to achieve chromatographic separation in comparison to the NIST computer library.

MTT assay

Prostate cancer cells (PC3) procured from NCCS Pune; were harvested in T-25 flasks for the *in vitro* studies. PC3 cells were trypsinized and aspirated into a 5 ml centrifuge tube. After centrifugation at 300 rpm for 10 min, the cell pellet was separated. The cell count was adjusted using DMEM HG medium so that 200 µl of suspension contained approximately 10,000 cells. In an ESCO model CLM170B-8-UV CO_2 incubator, a 200 µl cell suspension was added to each well of the 96-well microtiter plate, and the plate was incubated for 24 h at 37°C and 5% CO_2 atmosphere. After 24 h, the spent medium was aspirated. In each well, 200 µl of various test drug concentrations and the standard drug cisplatin were added. After that, the plates were incubated for 24 h at 37°C and 5% CO_2. The drug-containing media was aspirated after the plate was removed from the incubator. The plate was then incubated for 3 h at 37\u00B0C and 5% CO_2 atmosphere with 200 µl of medium containing 10% MTT reagent in each well to achieve a final concentration of 0.5 mg/ml. The culture medium was completely removed without disturbing the formed crystals. To solubilize the formed formazan, the plate was gently shaken in a gyrator shaker with 100 µl of solubilization solution (DMSO). The absorbance was read at 570 and 630 nm using the microplate reader of a Multiskan sky ELISA spectrophotometer.

Results and discussion

The Mangrove region in Jeppinamogaru located at Mangalore, India, served as a suitable source for isolating *G. mysorens* strain. The *G. mysorens* strain received a GenBank accession number MW647910.1 and was isolated and their biological activities were reported by Karthik and Kalyani (2021). In continuation to previous work; initially, the *G. mysorens* strain was observed for morphological characteristics after performing FESEM analysis. Also, biologically important chemical components present in the intracellular extract of the *G. mysorens* strain were characterized using GCMS and a partially purified protein sample

was characterized using LCMS and have a shown significant number of bioactive compounds.

The cultural characteristics of mangrove adapted *G. mysorens* strain upon growth on starch casein nitrate agar medium exhibited as white colored filamentous mycelia and at maturity showed ash-colored spores. Production of brown pigmentation on SCNA media was observed. Further microscopic analysis showed Gram staining positive. The isolate when further subjected to FESEM microscopic studies revealed mycelial morphological characteristics of the genus *Glutamicibacter.* Further, the culture showed filamentous mycelia possessing spirally coiled spore chains. Each spore is visualized as an elongated cylindrical hairy appearance with curved edges as shown in Figure 1. The *G. mysorens* when grown on different *Actinomyces*-specific media have shown distinctive phenotypic characteristics as listed in Table 1. Excellent growth was achieved on starch casein nitrate agar, whereas good growth was seen on, glucose leucine agar, yeast extract agar, and nutrient agar media. Moderate growth was seen on sucrose peptone agar, and malt extract agar. Whereas in another study, lysogeny agar was chosen as the best growth media for *G. mysorens* according to Wang Y. et al. (2022) and Deb et al. (2020).

In our previous report, the *G. mysorens* strain when subjected to simple and rapid disruption followed according to the method of Bhaduri yielded significant intracellular extraction in buffer (Bhaduri and Demchick, 1983). A 20 mg of protein was loaded on top of the column and 2 ml fractions were collected and about 2.5 times (216 ml) bed volumes of protein elutions were collected. The absorbance of protein fractions was checked at 280 nm and graphs were plotted. The

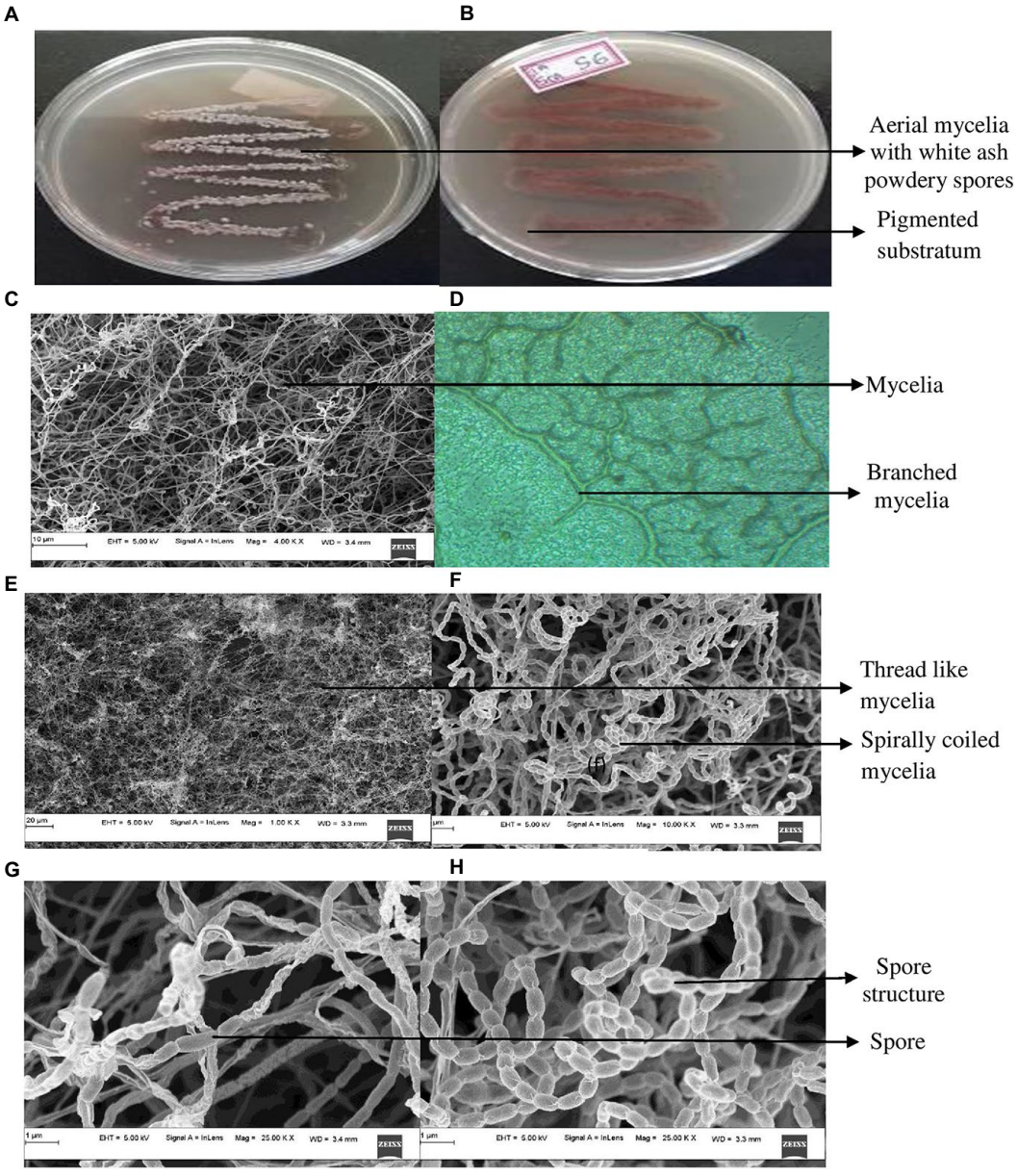

FIGURE 1
Cultural characteristics of *Glutamicibacter mysorens*. **(A)** Front view of isolate. **(B)** Rear view of isolate. **(C)** Mycelia observations under FESEM. **(D)** Phase contrast microscopic analysis. **(E,F)** Mycelia along with spore analysis under FESEM. **(G,H)** Spore structure analysis using FESEM.

X-axis indicates fraction numbers and absorbance plotted on Y-axis for each fraction collected from Sephadex G-10 column chromatography as showed in Figure 2. This column separation chromatography purifies 10.66 folds as detailed in Table 2. The GCMS studies depicted the presence of 155 bioactive molecules present in the intracellular extract of *G. mysorens* and the obtained elution profile is as shown in Figure 3. Whereas GCMS analysis depicted the highest probable compounds such as Cyclopentane undecanoic acid, methyl ester 22.7% and Glutaric acid, 2,2-dichloroethyl 3-fluorophenyl ester 34% probability as shown in Figure 4. All the compounds detected through GCMS showed low molecular weight below 1Kgmol^{-1}with various pharmacological applications. The majority of bioactive compounds have shown antimicrobial, enzyme inhibitors, activators, antioxidants, anti-inflammatory, anticancer, agrochemical, insecticide, anti-obese, and many other applications as listed in Table 3. The intracellular extract of *G. mysorens* had shown potent antimicrobial activity to a broad spectrum of test pathogens such as *Salmonella typhimurium* (ATCC23564), *Staphylococcus aureus* (ATCC6538P), *Pseudomonas aeruginosa* (ATCC9027), *Proteus vulgaris* (ATCC13315), and *Bacillus cereus* (ATCC10876) cultures. In order to focus further on prominent bioactive compounds the intracellular extract was partially purified using a Sephadex G-10 column. The eluted peak fraction upon spectrophotometry and electrophoretic analysis revealed the presence of peptide and is reported in our previous article (Karthik and Kalyani, 2021). A similar study was illustrated on 41 different *Actinomyces* species and majority isolates shown antagonist activity against *Staphylococcus aureus, Escherichia coli* and *Klebsiella pneumoniae* (Sapkota et al., 2020).

One of the previous study; extracellular protein of *Actinomyces* are actively producers for enzyme ligno cellulase (Clark Mason et al., 1988). The eluted peak fraction for proteins of *G. mysorens* has shown significant activity for different concentrations 50 µg of protein fraction showed 24% antiproliferative activity against prostate cancer PC3 cell line, for 100 µg 35% antiproliferative activity was observed, for 150 µg 47% antiproliferative activity was observed and for 200 µg 56% antiproliferative activity was observed in comparison with standard drug cisplatin at 5 µg showed 47% antiproliferative activity as showed in Figure 5.

Similar studies reported that other bioactive compounds isolated from the genus *Glutamicibacter* have been characterized for antimicrobial activity (Phuong and Diep, 2020; Xiong et al., 2020). In another study reported that plant-growth promoting bioactive

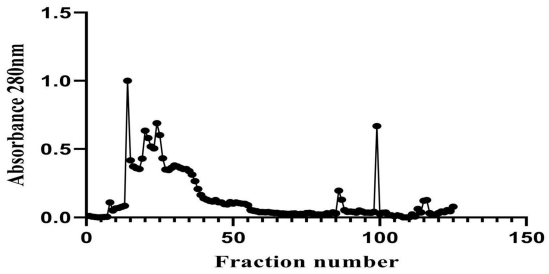

FIGURE 2
Elution profile of *Glutamicibacter mysorens* by using Sephadex G-10 column chromatography.

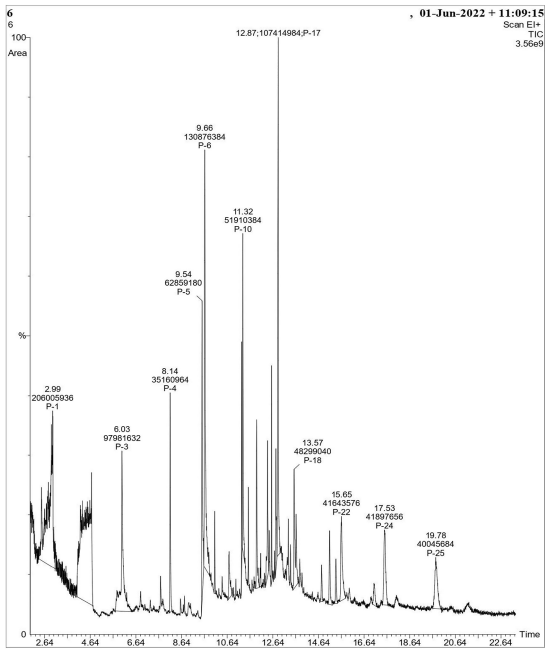

FIGURE 3
Elution profile of GCMS analysis for *Glutamicibacter mysorens* intracellular extract.

TABLE 1 Phenotypic characteristics of *Glutamicibacter mysorens* on different media.

Media	Growth	Front view	Rear view	Pigment	Spores
Sucrose peptone agar	Moderate	Cream	Creamish white	–	No
Glucose luecine agar	Good	Cream	White	–	Black
Nutrient agar	Good	Creamish	Creamish	–	–
Malt extract agar	Moderate	Creamish white	Creamish white	–	No
Yeast extract agar	Good	Cream	Cream	–	White
Starch casein nitrate agar	Excellent	White ash	Brown	+	Grey

TABLE 2 Purification chart of *Glutamicibacter mysorens* intracellular protein.

Sample	Protein (mg/ml)	Fold purification	% yield
Crude protein	2.0	1	100
Gel filtration (Sephadex G-10)	0.1875	10.66	9.38

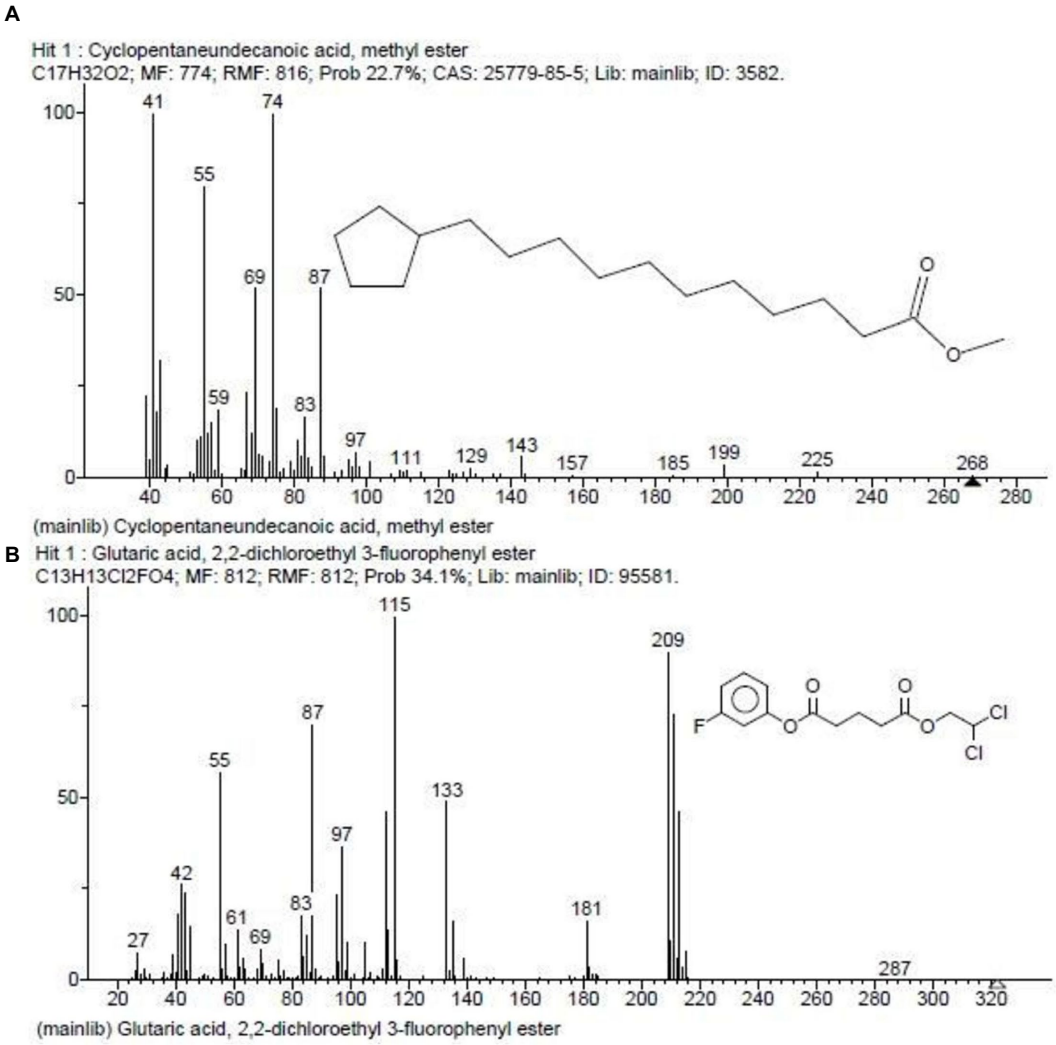

FIGURE 4
GCMS depicted highest probable compounds. **(A)** Cyclopentaneundecanoic acid, methyl ester 22.7%. **(B)** Glutaric acid, 2,2-dichloroethyl 3-fluorophenyl ester 34% probability.

compounds was produced by *Glutamicibacter halophytocola* coastal region of China (Qin et al., 2018). Whereas another study describes the anti-fungal efficiency of the *Glutamicibacter* genus with chitin hydrolyzing activity (Asif et al., 2020). The intracellular protein extraction already reported in our previous studies characterized for an antimicrobial activity that can be considered as antimicrobial peptides (AMPs) from the microbial origin (Karthik and Kalyani, 2021). In the present work the *G. mysorens* protein fraction is also exhibiting antiproliferative activity against cancerous cells acting also as anticancer peptides (ACP's) and the protein molecules detected and characterized by LC–MS analysis. We are also reporting GCMS analysis and detected bioactive compounds from *G. mysorens*.

As discussed above the Sephadex G-10 eluted peak protein fraction was further subjected to LCMS analysis. The LCMS analysis and elution profile as shown in Figure 6, revealed the detection of pharmacologically applicable bioactive peptide compounds. With respect to elution peak from LCMS analysis and detection through the NIST, the computer library resulted in the identification of Kinetin-9-riboside and Embinin. The detected Kinetin-9-riboside with 347 Da molecular weight structure and mass confirmation are shown in Figure 7. The mass confirmation and structure of Embinin with a molecular weight of 606 Da showed in Figure 8. These bioactive molecules are well-known for their effective activity in various biological applications.

In a previous study, the therapeutic and biological studies of Kinetin-9-riboside as an immuno-stimulant; immuno-stimulatory activities, and their uses as an adjuvant were reported. Because mutations in induced putative kinase 1 (PINK1) induce severe Parkinson's disease, there's a lot of interest in finding small molecules that boost PINK1's kinase activity. Several studies on the design, synthesis, serum stability and hydrolysis of four kinetin riboside ProTides have been published. These ProTides, in combination with kinetin riboside, activated PINK1 in cells that had not been depolarized by mitochondria. This demonstrates the therapeutic potential of modified nucleosides and their phosphate prodrugs for Parkinson's disease, the second most common neurodegenerative disease (Osgerby et al., 2017).

10.3389/fmicb.2023.1096826

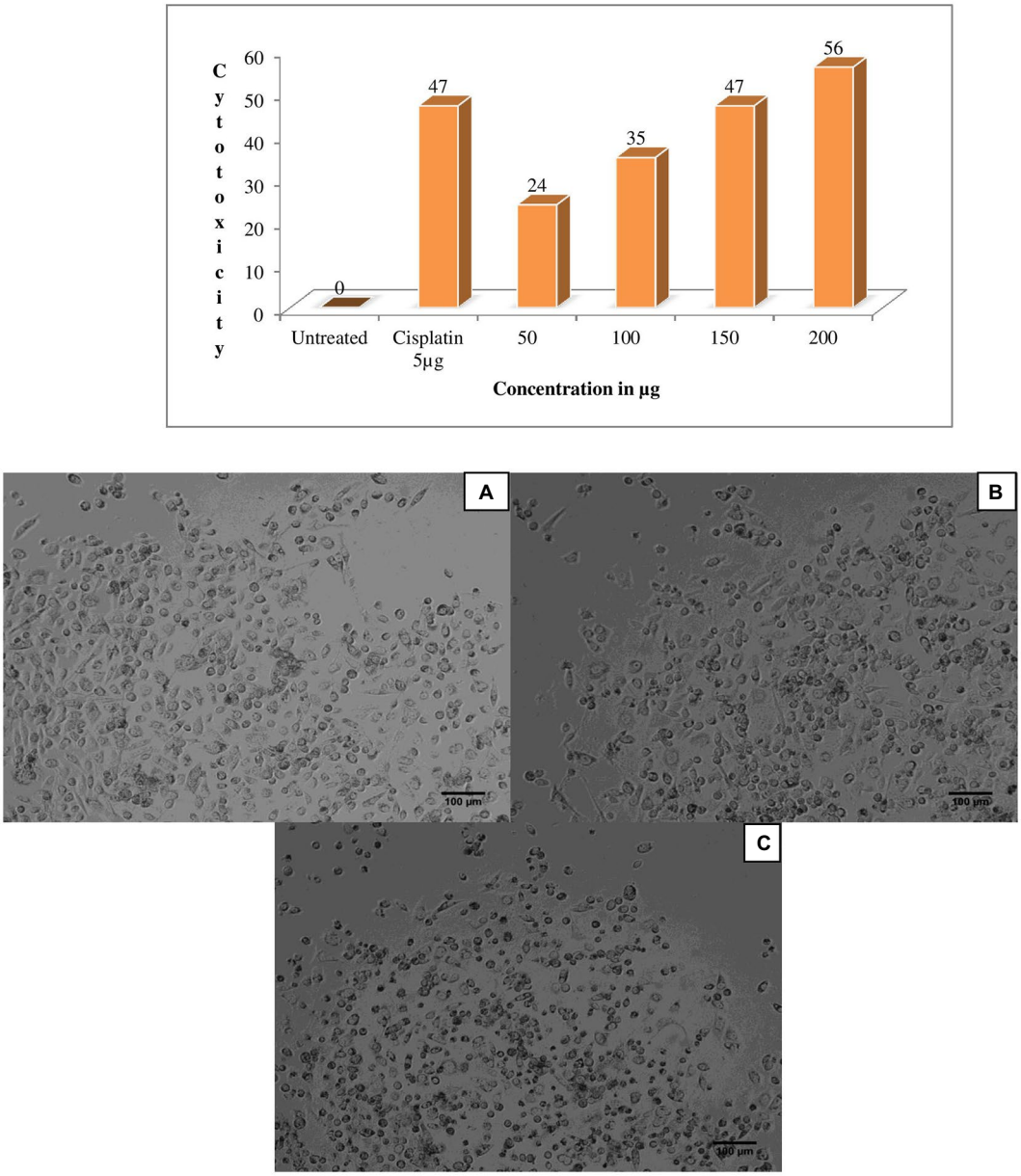

FIGURE 5
Anticancer activity of *Glutamicibacter mysorens* strain protein. MTT assay performed by using prostate cancer PC3 cell line. **(A)** Untreated cells of PC3 cell line, **(B)** Standard cisplatin at 5µg/ml, **(C)** 56% Anticancer activity of *Glutamicibacter mysorens* protein at 200µg/ml.

Another study found that the epithelial-mesenchymal transition (EMT) is a molecular phenomenon associated with increased vimentin expression and raised activity of transcriptional factors (Snail, Twist) that inhibit E-cadherin. EMT has been linked to prostate cancer metastatic potential, therapy resistance, and poor outcomes. Kinetin riboside (KR) is a naturally occurring cytokinin with effective anticancer activity against several human cancer cell lines. mRNA and protein levels of AR, E-, N-cadherins, Vimentin, Snail, Twist, and MMPs were measured using Western Blot and RT-PCR or RQ-PCR techniques to determine the effect of KR on human prostate cell lines.KR inhibited the growth of human prostate cancer cells and, to a lesser extent, normal cells. The cell type and androgen sensitivity determined this effect. KR also decreased the level of p-Akt, which is involved in androgen signaling modulation. When cancer cell lines are exposed to KR, the anti-apoptotic Bcl-2 protein is down-regulated, whereas the Bax protein is up-regulated. KR was involved in E-cadherin re-expression as well as pivotal changes in cell migration. Taken together, the findings suggest that, for the first time, KR can be anticipated as a factor for signaling pathway regulation that involves the inhibition of the development of aggressive forms of prostate cancer, potentially leading to future therapeutic interventions. As a result, research indicates that KR is an effective inhibitor of EMT in human prostate cells (Thakor et al., 2016; Dulińska-Litewka et al., 2020).

Whereas Embinin is a C-Glycosyl flavone and has a wide therapeutic applications in cardiovascular diseases (Ivkin et al.,

TABLE 3 List of GC–MS analysis of bioactive compounds from *Glutamicibacter mysorens* intracellular extract.

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
1	4.5	2-Pentanone, 4-hydroxy-4-methyl-	Photolysis	$C_6H_{12}O_2$	116	0.9	Qiu et al. (2019)
2		Tert-Butyl Hydroperoxide	Oxidant	$C_4H_{10}O_2$	90		Gad (2014)
3		1,3-Dioxolane-2-methanol, 2,4-dimethyl-	Chlorinating agent	$C_6H_{12}O_3$	132		Simon and Losada (2008), Fuentes et al. (2016)
4		2-Propanol, 2-nitroso-, acetate	Cosmetics	$C_5H_9NO_3$	131		Lemieux and Nagabhushan (1968)
5		2-Hexanone, 4-methyl-	Paints	$C_7H_{14}O$	114		Rebbert and Ausloos (1962)
6		2-Acetoxyisobutyryl chloride	Epoxides synthesis	$C_6H_9ClO_3$	164		Zibuck (2001)
7	6.0	Octanoic acid, methyl ester	Oxidation	$C_9H_{18}O_2$	158	8.6	Schwabe et al. (1964)
8		Undecanoic acid, 2-methyl-	Antifungal	$C_{12}H_{24}O_2$	200		Rossi et al. (2021)
9		Methyl 6-methyl heptanoate	Biomolecule synthesis	$C_9H_{18}O_2$	158		Kroumova and Wagner (2003)
10		Decanoic acid, methyl ester	Antibacterial	$C_{11}H_{22}O_2$	186		Damiano et al. (2020)
11	6.8	Dodecanoic acid, 3-hydroxy-	Cytotoxic	$C_{12}H_{24}O_3$	216	5.3	Viegas et al. (1989)
12		Oleic Acid	Anti-tumor	$C_{18}H_{34}O_2$	282		Carrillo Perez et al. (2012)
13		12-Methyl-E,E-2,13-octadecadien-1-ol	Antioxidant	$C_{19}H_{36}O$	280		Salem et al. (2016)
14		Z-8-Methyl-9-tetradecenoic acid	Antibacterial	$C_{15}H_{28}O_2$	240		Jawad et al. (2016)
15		Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	Anti-inflammatory	$C_{16}H_{28}O_3$	268		Abdul et al. (2020)
16		trans-13-Octadecenoic acid/ cis-Vaccenic acid	Anti-protozoal/ Protects from Heart failure	$C_{18}H_{34}O_2$	282		Carballeira et al. (2009), Djoussé et al. (2014)
17		7-Hexadecenoic acid, methyl ester, (Z)-	Antioxidant	$C_{17}H_{32}O_2$	268		Reza et al. (2021)
18		1-Octanol, 2,7-dimethyl-	Antioxidant, hepatoprotective and anti-inflammatory	$C_{10}H_{22}O$	158		Bentley et al. (2002)
19		Carbonic acid, prop-1-en-2-yl undecyl ester	Beverages production	$C_{15}H_{28}O_3$	256		Millero et al. (2006)
20		1-Decanol, 2-ethyl-	Surfactant	$C_{12}H_{26}O$	186		Achimon et al., 2022
21		1-Decanol, 2-methyl-	Lubricants, Plasticizers	$C_{11}H_{24}O$	172		Halling et al. (1998)
22		Trichloroacetic acid, decyl ester	Disinfectant	$C_{12}H_{21}Cl_3O_2$	302		Anand et al. (2014)
23		1-Heptanol, 2-propyl-	Pheromone	$C_{10}H_{22}O$	158		Francke and Schulz (1999)
24		1-Octanol, 2-butyl-	Antioxidant	$C_{12}H_{26}O$	186		Abdillah et al. (2015)
25		Carbonic acid, decyl prop-1-en-2-yl ester	Beverages production	$C_{14}H_{26}O_3$	242		Millero et al. (2006)
26	7.2	1,7-Octanediol, 3,7-dimethyl-	Polymer	$C_{10}H_{22}O_2$	174	8.6	Reddy and Ananthaprasad (2021)
27		Octanoic acid, 7-oxo–/ Methyl 6-oxoheptanoate	Antibacterial	$C_8H_{14}O_3$	158		Schwabe et al. (1964)
28		1,8-Nonanediol, 8-methyl-	Agrochemicals	$C_{10}H_{22}O2$	174		Kula et al. (2001)
29		7-Octen-2-ol, 2,6-dimethyl-	Cosmetics	$C_{10}H_{20}O$	156		Ham and Raymond Wells (2009)
30		3-Heptanol, 4-methyl-	Therapeutics	$C_8H_{18}O$	130		Ley and Madin (1991)

(Continued)

TABLE 3 (Continued)

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
31		4-Heptanone, 2,3:5,6-diepoxy-2,6-dimethyl-	Oxidant	$C_9H_{14}O_3$	170		Ley and Madin (1991)
32		3-Tridecanol	Lubricant	$C_{13}H_{28}O$	200		Chagnes et al. (2010)
33		2-Dodecanone	Insecticide	$C_{12}H_{24}O$	184		Wang et al. (2019)
34	7.7	3-(Prop-2-enoyloxy)dodecane	Antibiotics	C15H28O2	240	5.3	Fadhil et al. (2018)
35		3-(Prop-2-enoyloxy)tetradecane	Phyto-constituent	$C_{17}H_{32}O_2$	268		Ezekwe et al. (2020)
36		2-Propenoic acid, 1-methylundecyl ester	Antibacterial	C15H28O2	240		Deryabin and Tolmacheva (2015)
37		5-(Prop-2-enoyloxy)pentadecane	Antimicrobial	$C_{18}H_{34}O_2$	282		Xue et al. (2017), Gadhi et al. (2019)
38		3-Cyclopropylcarbonyloxydodecane	Reducing Agent	$C_{16}H_{30}O_2$	254		Bolade et al. (2018)
39		9-Methyl-Z-10-pentadecen-1-ol	Antioxidant	$C_{16}H_{32}O$	240		Soleha et al. (2020)
40		Octadecane, 1-(ethenyloxy)-	Anti-corrosion	$C_{20}H_{40}O$	296		Zeitoun et al. (2021)
41		Dodecyl acrylate	Polyemerization	$C_{15}H_{28}O_2$	240		Buback and Kowollik (1999)
42		Octanoic acid, 2-propenyl ester	Antioxidant	$C_{11}H_{20}O_2$	184		Windey et al. (2012)
43	8.7	Octadecane, 6-methyl-	Enzymatic	$C_{19}H_{40}$	268	4.1	Holman et al. (1966)
44		Hydroxylamine, O-decyl-	Reducing agent	$C_{10}H_{23}NO$	173		(Gad, 2014)
45		Tetradecane, 2,6,10-trimethyl-	Hydrocarbon	$C_{17}H_{36}$	240		McCarthy and Calvin (1967)
46		Silane, trichlorodocosyl-	Surfactant	$C_{22}H_{45}Cl_3Si$	442		Janneck et al. (2018)
47		Nonadecane	Binding material	$C_{19}H_{40}$	268		Li et al. (2010)
48		Oxirane, [(hexadecyloxy)methyl]-	Antibacterial	$C_{19}H_{38}O_2$	298		Es (2014)
49		Decane, 1,1′-oxybis-	Antimicrobial	$C_{20}H_{42}O$	298		Fauzi et al. (2017)
50		1-Hexadecanol, 2-methyl-	Antioxidant	$C_{17}H_{36}O$	256		Hussein et al. (2015)
51		4-Hydroxy-4-methylhex-5-enoic acid, tert.-butyl ester	Hydrocarbon	$C_{11}H_{20}O_3$	200		Ming Miao and Zhi (2018)
52		Z,Z-2,5-Pentadecadien-1-ol	Pharmacological	$C_{15}H_{28}O$	224		Millero et al. (2006)
53		l-Gala-l-ido-octose	Neuritogenic, Anti-hyper cholesteromia	$C_8H_{16}O_8$	240		Jahan et al. (2020)
54		2-Cyclopropylcarbonyloxytridecane	aphrodisiac, anti-inflammatory, antihypertensive	$C_{17}H_{32}O_2$	268		Sridhar et al. (2016)
55		Imidazole, 2-amino-5-[(2-carboxy) vinyl]-	Therapeutic	$C_6H_7N_3O_2$	153		Shalini et al. (2010)
56	9.5	4-Ethylacridine/3H-indole, 2-methyl-3-phenyl-	Antioxidant	$C_{15}H_{13}N$	207	4.2	Hosseini Hashemi et al. (2015)), Britten and Smith (1972)
57							
58		4-Pyridinol 3,5-dichloro-2-ethyl-6-methyl-	Herbicide	$C_8H_9Cl_2NO$	205		Ransom et al. (2012)
59		5-Methyl-2-phenylindolizine/3-Methyl-2-phenylindole/2-Methyl-7-phenylindole	Antimicrobial, Antioxidant	$C_{15}H_{13}N$	207		Onocha et al. (2011)
60		Pyridine, 2,4-dichloro-5-thiocyanato-	Antimicrobial	$C_6H_2Cl_2N_2S$	204		Al-Salahi et al. (2010)

(Continued)

TABLE 3 (Continued)

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
61		Dichloroacetic acid, phenyl ester/ Benzoic acid, 2,5-dichloro-, methyl ester	Therapeutic	$C_8H_6Cl_2O_2$	204		Babar et al. (2008)
62		3,5-Dichloro-2,4-dimethyl-1-methoxybenzene	Anticancer	$C_9H_{10}Cl_2O$	204		Dhakal et al. (2020)
63		1-Chloroundecane	Precursor for fatty acid synthesis	$C_{11}H_{23}Cl$	190		Gensler and Thomas (1952)
64		Dodecane, 1-chloro-	Hydrocarbon	$C_{12}H_{25}Cl$	204		Moldoveanu (2019)
65		Tetradecane, 1-chloro-	Chlorination	$C_{14}H_{29}Cl$	232		Assassi et al. (2005)
66		Nonane, 1-chloro-	Hydrocarbon	$C_9H_{19}Cl$	162		Moldoveanu (2019)
67	10.0	Benzene, 1,4-bis(trifluoromethyl)-	Flurochrome	$C_8H_4F_6$	214		Skhirtladze et al. (2022)
68		Pyrimidine, 4,5-diamino-6-chloro-2-(trifluoromethyl)-	Transcriptional activator	$C_5H_4ClF_3N_4$	212		Palanki et al. (2000)
69		1H-Imidazole, 1-(2,2,3,3,3-pentafluoro-1-oxopropyl)-	Anticancer	$C_6H_3F_5N_2O$	214		Zhang et al. (2014)
70		Sulfaguanidine	Enzyme inhibitor	$C_7H_{10}N_4O_2S$	214		Akocak et al. (2021)
71		Anthracene, 2-chloro-	Antibacterial	$C_{14}H_9Cl$	212		de Bony et al. (1984)
72		Ethyl iodoacetate	Enzyme activator	$C_4H_7IO_2$	214		Tanaka and Hayashi (2008)
73		8-Methyl-4-(1-pyrrolidinyl) pyrido[3,2-c]pyridazine	Cancer therapies	$C_{12}H_{14}N_4$	214		Jubete et al. (2019)
74		[1,1'-Biphenyl]-4-carboxylic acid, 4′-hydroxy-	Precursor for synthesis of bioactive molecules	$C_{13}H_{10}O_3$	214		Patel et al. (2004)
75		Benzoic acid, 2-(1,2,4-triazol-3-yl-aminocarbonyl)-	Breast and prostate cancer therapy	$C_{10}H_8N_4O_3$	232		Jamieson et al. (2012)
76		Succinic acid, 2-methylpent-3-yl pentafluorobenzyl ester	Antioxidant	$C_{17}H_{19}F_5O_4$	382		Cullere et al. (2004)
77		1,1'-Biphenyl, 2-iodo-	Substrate	$C_{12}H_9I$	280		Fang et al. (2017)
78		Benzamide, N-(1,4,6-trimethyl-1H-pyrazolo[3,4-b]pyridin-3-yl)-	Substrate	$C_{16}H_{16}N_4O$	280		Jachak et al. (2006)
79		4-[N′-(4-Methoxy-benzoyl)-hydrazino]-4-oxo-butyric acid methyl ester	Antibacterial	$C_{13}H_{16}N_2O_5$	280		EL-Hashash et al. (2014)
80		Dibenzo[a,c]phenazine	Flurochrome	$C_{20}H_{12}N_2$	280		Xie et al. (2019)
81		Benzofuro[3,2-d]pyrimidine, 4-(2-pyridylthio)-	Therapeutic	$C_{15}H_9N_3OS$	279		Campos et al. (2022)
82		(9E)-Styrylanthracene	Luminophore	$C_{22}H_{16}$	280		Zhang et al. (2017)
83		1H-Purine-2,6-dione,3,7-dihydro-3-methyl-7-carboxymethyl-8-n-butyl	Anti-inflammatory	$C_{12}H_{16}N_4O_4$	280		Abou-Ghadir et al. (2014)
84		Methyl 2-phenyl-2,3-epoxyindan-1-one-3-carboxylate	Catalyst	$C_{17}H_{12}O_4$	280		Godwin et al. (2012)
85		Propyl N-(heptafluorobutyryl) pyroglutamate	Metabolite	$C_{12}H_{12}F_7NO_4$	367		Hušek et al. (2016)

(Continued)

TABLE 3 (Continued)

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
86	10.4	3-Trifluoroacetoxypentadecane	Antimicrobial	$C_{17}H_{31}F_3O_2$	324	1.3	Hussein et al. (2015)
87		3-Cyclopropylcarbonyloxytetradecane	Antioxidant, Cytotoxic and Antibacterial	$C_{18}H_{34}O_2$	282		Upgade and Bhaskar (2013)
88		10-Undecenoic acid, octyl ester	Antimicrobial	$C_{19}H_{36}O_2$	296		Van der Steen and Stevens (2009)
89		3-(Prop-2-enoyloxy)tetradecane	Antioxidant	C17H32O2	268		Ezekwe et al. (2020)
90		Z-10-Tetradecen-1-ol acetate	Pharmaceutical	$C_{16}H_{30}O_2$	254		Bolade et al. (2018)
91		5-Amino-2-methoxy-4-(1H-1,2,3,4-tetrazol-5-yl)phenol	Antimicrobial	$C_8H_9N_5O_2$	207		Arulmurugan and Kavitha (2010)
92		4H-Pyrido[1,2-a]pyrimidine-3-carboxamide, 6,7,8,9-tetrahydro-6-methyl-4-oxo-	Antimicrobial and antitumor	$C_{10}H_{13}N_3O_2$	207		Al-Taisan et al. (2010)
93		1-Adamantanecarboxamide, N,N-dimethyl—/ Pent-3-yn-2-ol, 2-cyclopropyl-5-(1-piperidyl)	Anticancer	$C_{13}H_{21}NO$	207		Su et al. (2012)
94		trans-4-Ethoxy-β-methyl-β-nitrostyrene/ Carbamic acid, 4-methoxyphenyl-, allyl ester	Cardiovascular therapy	$C_{11}H_{13}NO_3$	207		Alves-Santos et al. (2019)
95		Thiophen-2-methylamine, N-(2-fluorophenyl)-	Catalytic activity	$C_{11}H_{10}FNS$	207		Tanak et al. (2020)
96		2-(1-Piperidino)-3-nitropyridine	Antimicrobial	$C_{10}H_{13}N_3O_2$	207		Sivaprakash et al. (2019)
97		Benzoic acid, 4-amino-, pentyl ester	Cytotoxicity	$C_{12}H_{17}NO_2$	207		Kratky et al. (2019)
98	10.5	Cyclopentaneundecanoic acid, methyl ester	Antioxidant and Antibacterial	$C_{17}H_{32}O_2$	268	1.3	Daniels and Temikotan (2021)
99		Undecanoic acid, 10-methyl-, methyl ester	Antioxidant	$C_{13}H_{26}O_2$	214		Narra et al. (2017)
100		Methyl 8-methyl-nonanoate	Antimicrobial and Anti-inflammatory	$C_{11}H_{22}O_2$	186		Kaur et al. (2022)
101		Tetradecanoic acid, 12-methyl-, methyl ester	Larvicidial	$C_{16}H_{32}O_2$	256		Xu et al. (2008)
102		Cyclopentanetridecanoic acid, methyl ester	Cytotoxic	$C_{19}H_{36}O_2$	296		Joshi et al. (2020)
103	10.7	Glutaric acid, 2,2-dichloroethyl 3-fluorophenyl ester	Anti-angiogenic	$C_{13}H_{13}Cl_2FO_4$	322	1.0	Amaral et al. (2021)
104		Triethylgermanium bromide	Oxidant	$C_6H_{15}BrGe$	240		Satgé et al. (1973)
105		2,5-Cyclohexadien-1-one, 2,6-dichloro-4-(chloroimino)—/ benzene, 1,3,5-trichloro-2-nitroso-	Surfactant	$C_6H_2Cl_3NO$	209		Yamamoto (2002)
106		Pyridine, 3,4,5-trichloro-2,6-dimethyl-	Antimicrobial	$C_7H_6Cl_3N$	209		Khidre et al. (2011)
107		Ethaneselenoamide, N-(4-methylphenyl)-	Anticancer	$C_9H_{11}NSe$	213		Watanabe et al. (1997)
108		Stannane, chlorotriethyl-	Polymerization	$C_6H_{15}ClSn$	242		Qiu et al. (2013)
109		1-(2,4,5-Trichlorophenyl)ethanol	Cytotoxic	$C_8H_7Cl_3O$	224		Shawky et al. (2021)
110		1,3-Dioxolane, 2-(5,5,5-trichloro-3-penten-1-yl)-, (E)-	Flavoring agent	$C_8H_{11}Cl_3O_2$	244		Ivankin (2017)
111		benzene, 1,1′-[oxybis(methyleneoxy)] bis[2,4,6-trichloro-	Toxic agent	$C_{14}H_8Cl_6O_3$	434		Holman et al. (1966)

(Continued)

TABLE 3 (Continued)

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
112	11.5	Undecanoic acid	Antifungal	$C_{11}H_{22}O_2$	186	0.9	Rossi et al. (2021)
113		n-Decanoic acid	Beverage production	$C_{10}H_{20}O_2$	172		Viegas et al. (1989)
114		n-Hexadecanoic acid	Anti-inflammatory	$C_{16}H_{32}O_2$	256		Aparna et al. (2012)
115		4-(Benzoylmethyl)-6-methyl-2H-1,4-benzoxazin-3-one	Antimicrobial	$C_{17}H_{15}NO_3$	281		Ozden et al. (2000)
116		Adenine, N4-pentafluoropropionyl-	Oxidization	$C_8H_4F_5N_5O$	281		Tsunoda et al. (2011)
117		2-Furancarboxylic acid, N′-[(8-hydroxy-5-quinolinyl)methylidene] hydrazide	Antioxidant	$C_{15}H_{11}N_3O_3$	281		Gülerman et al. (2000)
118		1-Phenyl-4-(trifluoromethyl)-1H,4H,5H,6H,7H-pyrazolo[3,4-b] pyridin-6-one	Antiproliferative	$C_{13}H_{10}F_3N_3O$	281		Martín-Acosta et al. (2021)
119		Acetamide, 2-(2,4-difluorophenoxy)-N-(4-fluorophenyl)-	Inhibitor	$C_{14}H_{10}F_3NO_2$	281		Williams et al. (2015)
120		Succinic acid, 3,5-dinitrobenzyl 2-methylhex-3-yl ester	Enzyme activator	$C_{18}H_{24}N_2O_8$	396		Martinez et al. (2008)
121		Oxalic acid, monoamide, N-(2-fluorophenyl)-, heptyl ester	Antioxidant	$C_{15}H_{20}FNO_3$	281		Ganyam et al. (2019)
122		Propanamide, 2,2,3,3,3-pentafluoro-N-(2,4,6-trimethylphenyl)-	Inhibitor	$C_{12}H_{12}F_5NO$	281		Talley et al. (2000)
123	12.3	3-Trifluoroacetoxydodecane	Antioxidant	$C_{14}H_{25}F_3O_2$	282		Zagulyaeva et al. (2010)
124	12.5	Cyclopropanepentanoic acid, 2-undecyl-, methyl ester, trans-	Anti-mycobacterial	$C_{20}H_{38}O_2$	310	1.5	Carballeira et al. (2007)
125		13,16-Octadecadiynoic acid, methyl ester	Antioxidant	$C_{19}H_{30}O_2$	290		Hamalainen et al. (2001)
126		13-Tetradecynoic acid, methyl ester	Anti-inflammatory	$C_{15}H_{26}O_2$	238		James and Martin (1956)
127		Oxiraneundecanoic acid, 3-pentyl-, methyl ester, cis-	Antimicrobial	$C_{19}H_{36}O_3$	312		Al-Marzoqi et al. (2016)
128		9-Octadecenoic acid (Z)-, methyl ester/11-Octadecenoic acid, methyl ester	Food and Pharmacological	$C_{19}H_{36}O_2$	296		Jiang and Jia (2015)
129		13-Docosenoic acid, methyl ester	Food industires	$C_{23}H_{44}O_2$	352		Beare-Rogers (1977)
130	13.2	Z-(13,14-Epoxy)tetradec-11-en-1-ol acetate	Anti-inflammatory	$C_{16}H_{28}O_3$	268	2.0	Abdul et al. (2020)
131		12-Methyl-E,E-2,13-octadecadien-1-ol/2-Methyl-Z,Z-3,13-octadecadienol	Therapeutic	$C_{19}H_{36}O$	280		Adeyemi (2017)
132		Z-8-Methyl-9-tetradecenoic acid	Antimicrobial	$C_{15}H_{28}O_2$	240		Jawad et al. (2016)
133		Oxiraneoctanoic acid, 3-octyl-, cis-	Antimicrobial	$C_{18}H_{34}O_3$	298		Hussein et al., 2016
134		Pentadecanoic acid	Oxidation	$C_{15}H_{30}O_2$	242		Jenkins et al. (2015)
135		Heptadecanoic acid, heptadecyl ester	Antimicrobial	$C_{34}H_{68}O_2$	508		Gautam et al. (2016)
136		2-Myristynoyl pantetheine	Antimicrobial	$C_{25}H_{44}N_2O_5S$	484		Srivastava et al. (2015)
137		9-Octadecenoic acid, (E)-	Inhibitor	$C_{18}H_{34}O_2$	282		Carrillo Perez et al. (2012)
138		9-Hexadecenoic acid/1,2-15,16-Diepoxyhexadecane	Cosmetics	$C_{16}H_{30}O_2$	254		Takigawa et al. (2005)
139		cis-13-Eicosenoic acid	Anti-obesity	$C_{20}H_{38}O_2$	310		Senarath et al. (2018)
140		3-Heptafluorobutyroxytetradecane	Polymerization	$C_{18}H_{29}F_7O_2$	410		MacKenzie and Tenaschuk (1979)
141		n-Nonadecanol-1	Antifeedant	$C_{19}H_{40}O$	284		Aznar-Fernandez et al. (2019)

(Continued)

10.3389/fmicb.2023.1096826

TABLE 3 (Continued)

Sl. No.	R.T (min)	Compound name	Activity/ Applications	Molecular formula	Molecular weight (g/mol)	Area percentage	References
142	14.7	Hexanedioic acid, mono(2-ethylhexyl) ester	Antibacterial	$C_{14}H_{26}O_4$	258	0.4	Choi and Jiang (2014)
143		Hexanedioic acid, dioctyl ester	Inhibitor	$C_{22}H_{42}O_4$	370		Chaler et al. (2004)
144		Cyclohexanecarboxylic acid, octyl ester		$C_{15}H_{28}O_2$	240		Andersson et al. (1965)
145		1-Dodecanol, 3,7,11-trimethyl-	Cytotoxic	$C_{15}H_{32}O$	228		Fahem et al. (2020)
146		Cyclohexanecarboxylic acid, decyl ester/2-Propenoic acid, tetradecyl ester	Antioxidant	$C_{17}H_{32}O_2$	268		Matthew et al. (2022)
147		Hexanedioic acid, bis(2-ethylhexyl) ester	Biomarker	$C_{22}H_{42}O_4$	370		Silva et al. (2013)
148	15.3	10-Octadecenal/4-Octadecenal	Adjuvant/ pheromones	$C_{18}H_{34}O$	266	0.4	Gil et al. (1995)
149		Cyclopropanetetradecanoic acid, 2-octyl-, methyl ester	Pharmacological	$C_{26}H_{50}O_2$	394		Srivastava et al. (2015)
150		9-Methyl-Z-10-pentadecen-1-ol	Antioxidant	$C_{16}H_{32}O$	240		Soleha et al. (2020)
151		Hexadecane, 1,1-bis(dodecyloxy)-		$C_{40}H_{82}O_2$	594		Ser et al. (2015)
152		3-Chloropropionic acid, heptadecyl ester	Antibiotic	$C_{20}H_{39}ClO_2$	346		Ikhsanov et al. (2018)
153		2-Tridecenoic acid, (E)-	Antimicrobial	$C_{13}H_{24}O_2$	212		Chowdhury et al. (2021)
154		trans-2-undecenoic acid	Larvicidal	$C_{11}H_{20}O_2$	184		Saxena and Stotzky (2001)
155		Ethanol, 2-(octadecyloxy)-	Antimicrobial	$C_{20}H_{42}O_2$	314		Jaffar et al. (2015)

*R.T (min): Retention Time.

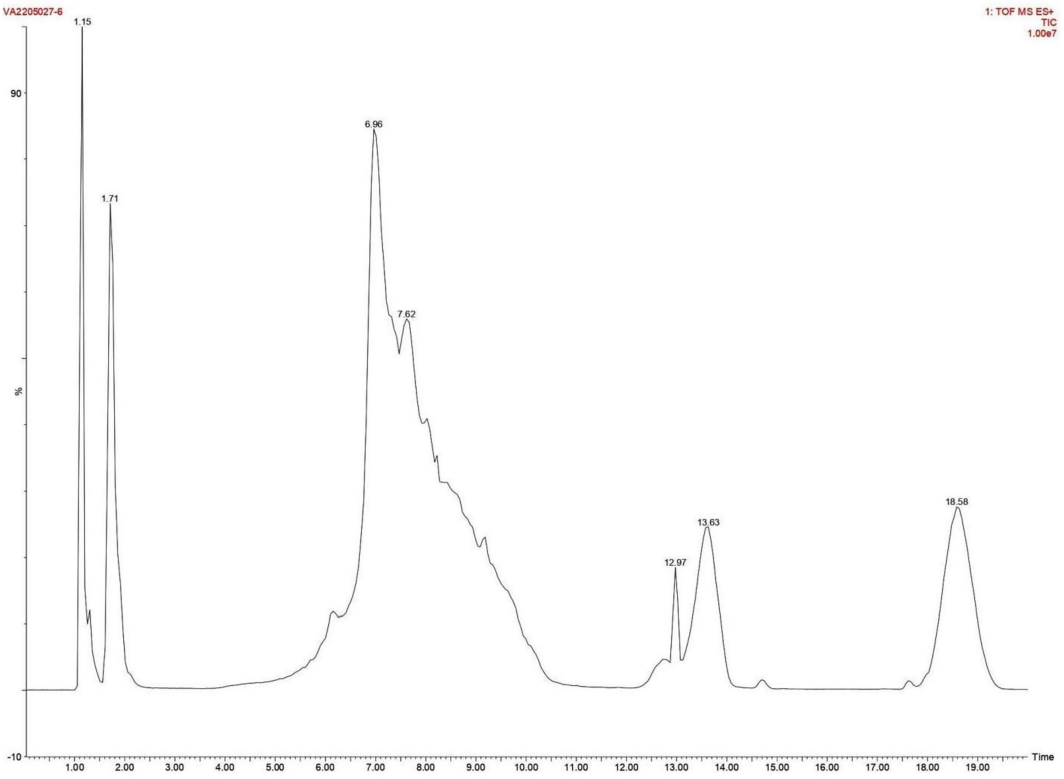

FIGURE 6
Elution profile of intracellular protein extract from *Glutamicibacter mysorens* by LCMS.

10.3389/fmicb.2023.1096826

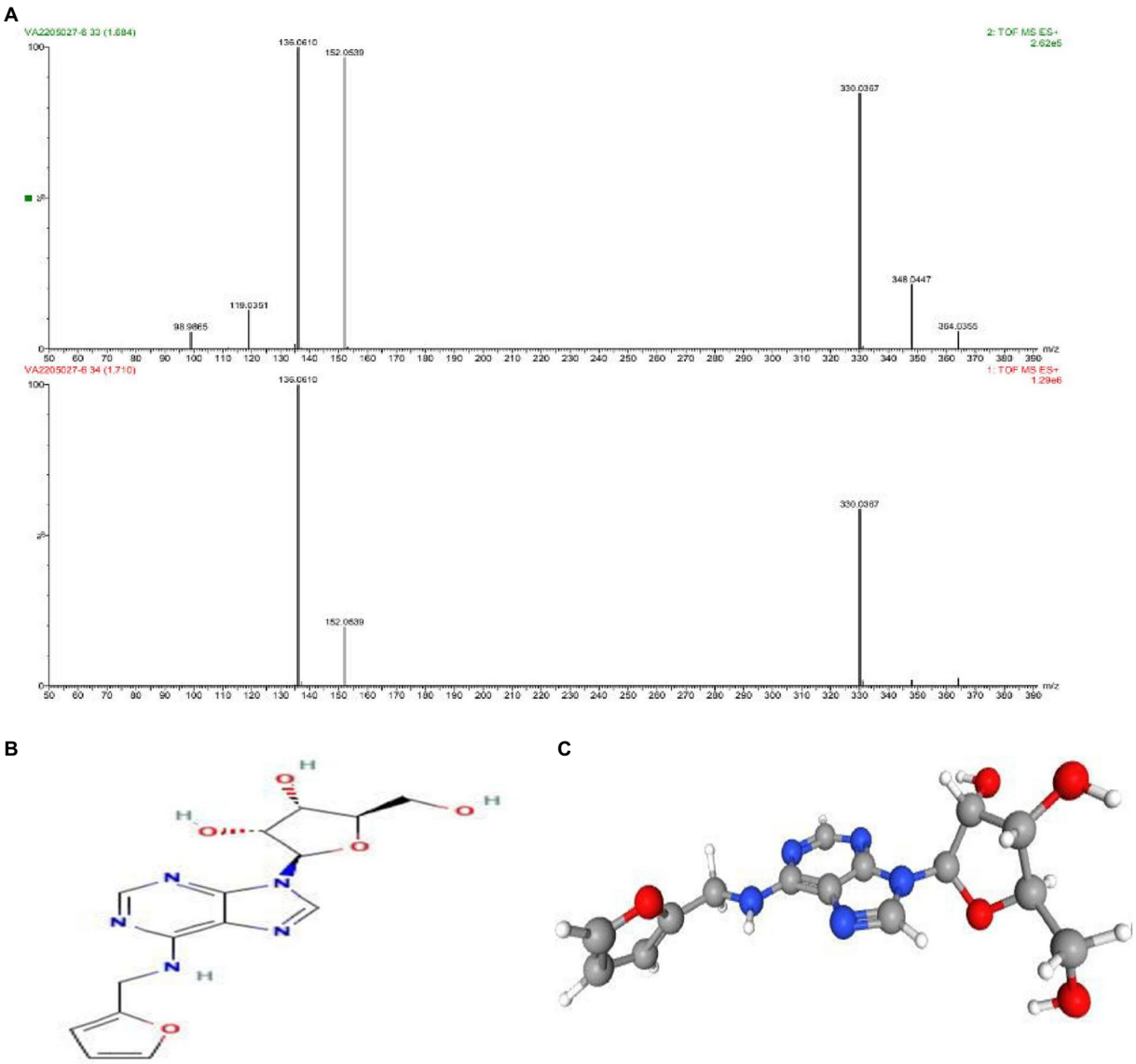

FIGURE 7
(A) Mass confirmation and analysis record. **(B)** 2D structure of kinetin-9-ribose, **(C)** 3D structure of kinetin-9-ribose molecule.

2018). Another study reports the production of Embinin frompetals of *Iris germanica* Linnaeus and *Iris lactea* Leaves (Kawase and Yagishita, 1968; Chen et al., 2018). Our study elucidates the cytotoxicity activity of *G. mysorens* bioactive peptide as characterized by LCMS/MS revealed the presence of Kinetin-9-Riboside and Embininin the peptide fraction showing its antiproliferative effect on the prostate cancer cell line. Thus microbial-originated intracellular peptides have potential antimicrobial (AMPs) and anticancer (ACPs) have been significantly substantiated in our studies.

Conclusion

The present study is illustrative for exploring untapped mangrove habitat in the Mangalore region of Karnataka. In our study, we could demonstrate that mangrove *G. mysorens* is an efficient microbe to produce bioactive compounds and enzymes responsible for both antimicrobial and anticancer activity. The antimicrobial potentiality was detailed in our previous article. In this present study; anticancer activity on prostate cancer cell lines and to treat various other related ailments. Peptides from reliable sources such as *Actinomyces* could be demonstrated as having dual roles as AMPs as well as ACPs. Hence, this study supports and proves that the genus *Glutamicibacter* is an effective microbial group for the isolation of peptides to treat multidrug-resistant pathogens.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: NCBI - MW647910.

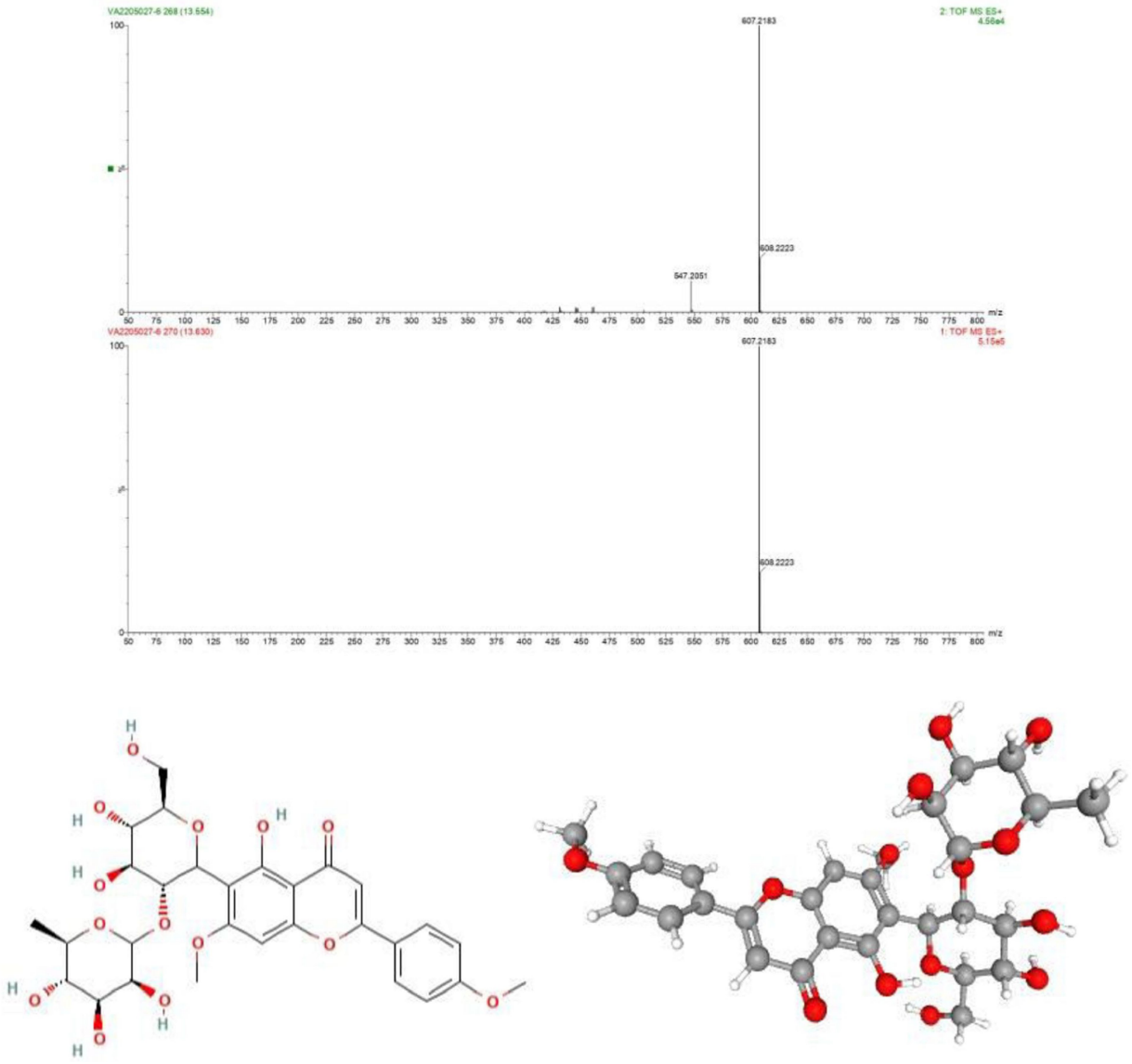

FIGURE 8
(A) Mass confirmation of Embinin, **(B)** 2D structure of Embinin, **(C)** 3D structure of Embinin.

Author contributions

YK conducted the research and wrote the manuscript. MI, SK, RD, and CA performed the data analyses and reviewed the manuscript. SK, YK, KR, MAh, MAl, MH, AA, SS, and MM edited and reviewed the manuscript. MI provided experimental support, planned, supervised, and organized the experiment, and wrote and reviewed the manuscript. All authors contributed to the article and approved the submitted version.

Funding

This work is supported by Science & Engineering Research Board, DST, Govt. of India and Vision Group of Science and Technology Govt. of Karnataka by providing financial and equipment grants.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

Abd-Elnaby, H., Abo-Elala, G., Abdel-Raouf, U., Abd-elwahab, A., and Hamed, M. (2016). Antibacterial and anticancer activity of marine Streptomyces parvus: optimization and application. *Biotechnol. Biotechnol. Equip.* 30, 180–191. doi: 10.1080/13102818.2015.1086280

Abdillah, S., Tambunan, R. M., Farida, Y., Sandhiutami, N. M. D., and Dewi, R. M. (2015). Phytochemical screening and antimalarial activity of some plants traditionally used in Indonesia. *Asian Pac. J. Trop. Dis.* 5, 454–457. doi: 10.1016/S2222-1808(15)60814-3

Abdul, K., Shaheed, A., Imtair, N., Awi, A. N., Kariem, A., Abbas, Z., et al. (2020). Analysis of bioactive phytochemical compound of (*Cyperus iria* L.) by using gas chromatography -mass spectrometry.

Abou-Ghadir, O., Alaa, M. H., Abdel-Moty, S., and Hussein, M. (2014). Design and synthesis of some new purine-dione derivatives of potential anti-inflammatory activity. *Der Pharma Chem.* 6, 199–211.

Achimon, F., Brito, V. D., Pizzolitto, R. P., and Zygadlo, J. A. (2022). Effect of carbon sources on the production of volatile organic compounds by Fusarium verticillioides. *J. Fungi* 8:158. doi: 10.3390/jof8020158

Adeyemi, M. (2017). Phytochemical analysis and GC-MS determination of Lagenaria breviflora R. Fruit. *Int. J. Pharmacogn. Phytochem. Res.* 9, 1045–1050. doi: 10.25258/phyto.v9i07.11178

Agamennone, V., Roelofs, D., van Straalen, N., and Janssens, T. K. S. (2018). Antimicrobial activity in culturable gut microbial communities of springtails. *J. Appl. Microbiol.* 125, 740–752. doi: 10.1111/jam.13899

Akocak, S., Taslimi, P., Lolak, N., Işık, M., Durgun, M., Budak, Y., et al. (2021). Synthesis, characterization, and inhibition study of novel substituted Phenylureido Sulfaguanidine derivatives as α-glycosidase and cholinesterase inhibitors. *Chem. Biodivers.* 18:e2000958. doi: 10.1002/cbdv.202000958

Al-Marzoqi, A., Hadi, M., and Hameed, I. (2016). Determination of metabolites products by Cassia angustifolia and evaluate antimicobial activity. *J. Pharmacogn. Phytother.* 8, 25–48. doi: 10.5897/JPP2015.0367

Alongi, D. M. (2015). The impact of climate change on mangrove forests. *Curr. Clim. Change Rep.* 1, 30–39. doi: 10.1007/s40641-015-0002-x

Al-Salahi, R. A., Al-Omar, M. A., and Amr, A. E.-G. E. (2010). Synthesis of chiral macrocyclic or linear pyridine carboxamides from pyridine-2,6-dicarbonyl dichloride as antimicrobial agents. *Molecules* 15, 6588–6597. doi: 10.3390/molecules15096588

Al-Taisan, K. M., Al-Hazimi, H. M. A., and Al-Shihry, S. S. (2010). Synthesis, characterization and biological studies of some novel thieno[2,3-d]pyrimidines. *Molecules* 15, 3932–3957. doi: 10.3390/molecules15063932

Alves-Santos, T. R., Silva, O. A., Moreira, H. S., Borges, R. S., Duarte, G. P., Magalhães, P. J. C., et al. (2019). Cardiovascular effects of trans-4-Methoxy-β-nitrostyrene in spontaneously hypertensive rats: comparison with its parent drug β-nitrostyrene. *Front. Pharmacol.* 10:1407. doi: 10.3389/fphar.2019.01407

Amaral, A. U., Ferreira, G. C., Seminotti, B., Leipnitz, G., and Wajner, M. (2021). "Glutaric acid neurotoxicity: mechanisms and actions" in *Handbook of neurotoxicity*. ed. R. M. Kostrzewa (Cham: Springer International Publishing), 1–35.

Anand, S. S., Philip, B. K., and Mehendale, H. M. (2014). "Chlorination byproducts" in *Encyclopedia of toxicology*. ed. P. Wexler. *Third* ed (Oxford: Academic Press), 855–859.

Andersson, L., Nilsson, I. M., Niléhn, J.-E., Hedner, U., Granstrand, B., and Melander, B. (1965). Experimental and clinical studies on AMCA, the antifibrinolytically active isomer of p-Aminomethyl cyclohexane carboxylic acid. *Scand. J. Haematol.* 2, 230–247. doi: 10.1111/j.1600-0609.1965.tb01300.x

Aparna, V., Dileep, K. V., Mandal, P. K., Karthe, P., Sadasivan, C., and Haridas, M. (2012). Anti-inflammatory property of n-hexadecanoic acid: structural evidence and kinetic assessment. *Chem. Biol. Drug Des.* 80, 434–439. doi: 10.1111/j.1747-0285.2012.01418.x

Arulmurugan, S., and Kavitha, H. (2010). 2-Methyl-3-{4-[2-(1H-tetrazol-5-yl) ethylamino]phenyl}-3H-quinazolin-4-one. *Mol. Ther.* 2010, 1–5. doi: 10.3390/M695

Asif, T., Javed, U., Zafar, S. B., Ansari, A., Ul Qader, S. A., and Aman, A. (2020). Bioconversion of colloidal chitin using novel Chitinase from *Glutamicibacter uratoxydans* exhibiting anti-fungal potential by hydrolyzing chitin within fungal Cell Wall. *Waste Biomass Valor* 11, 4129–4143. doi: 10.1007/s12649-019-00746-2

Assassi, N., Tazerouti, A., and Canselier, J. (2005). Analysis of chlorinated, sulfochlorinated and sulfonamide derivatives of n-tetradecane by gas chromatography/mass spectrometry. *J. Chromatogr. A* 1071, 71–80. doi: 10.1016/j.chroma.2005.01.102

Aznar-Fernandez, T., Cimmino, A., Masi, M., Rubiales, D., and Evidente, A. (2019). Antifeedant activity of long-chain alcohols, and fungal and plant metabolites against pea aphid (*Acyrthosiphon pisum*) as potential biocontrol strategy. *Nat. Prod. Res.* 33, 2471–2479. doi: 10.1080/14786419.2018.1452013

Babar, T., Qadeer, G., Rama, N., Ruzicka, A., and Padelkova, Z. (2008). Methyl 2,5-dichlorobenzoate. *Acta Crystallogr. Sect. E: Struct. Rep. Online* 64:o1970. doi: 10.1107/S1600536808029541

Baig, U., Dahanukar, N., Shintre, N., Holkar, K., Pund, A., Lele, U., et al. (2021). Phylogenetic diversity and activity screening of cultivable actinobacteria isolated from marine sponges and associated environments from the western coast of India. *Access Microbiol.* 3:000242. doi: 10.1099/acmi.0.000242

Beare-Rogers, J. L. (1977). Docosenoic acids in dietary fats. *Prog. Chem. Fats Other Lipids* 15, 29–56. doi: 10.1016/0079-6832(77)90006-4

Bentley, S. D., Chater, K. F., Cerdeño-Tárraga, A.-M., Challis, G. L., Thomson, N. R., James, K. D., et al. (2002). Complete genome sequence of the model actinomycete Streptomyces coelicolor A3(2). *Nature* 417, 141–147. doi: 10.1038/417141a

Bhaduri, S., and Demchick, P. H. (1983). Simple and rapid method for disruption of bacteria for protein studies. *Appl. Environ. Microbiol.* 46, 941–943. doi: 10.1128/aem.46.4.941-943.1983

Bharadwaj, R. P., Raju, N. G., and Chandrashekharaiah, K. S. (2018). Purification and characterization of alpha-amylase inhibitor from the seeds of underutilized legume, *Mucuna pruriens*. *J. Food Biochem.* 42:e12686. doi: 10.1111/jfbc.12686

Bolade, O. P., Akinsiku, A. A., Adeyemi, A. O., Williams, A. B., and Benson, N. U. (2018). Dataset on phytochemical screening, FTIR and GC–MS characterisation of *Azadirachta indica* and *Cymbopogon citratus* as reducing and stabilising agents for nanoparticles synthesis. *Data Brief* 20, 917–926. doi: 10.1016/j.dib.2018.08.133

Borker, S. S., Thakur, A., Kumar, S., Kumari, S., Kumar, R., and Kumar, S. (2021). Comparative genomics and physiological investigation supported safety, cold adaptation, efficient hydrolytic and plant growth-promoting potential of psychrotrophic *Glutamicibacter arilaitensis* LJH19, isolated from night-soil compost. *BMC Genomics* 22:307. doi: 10.1186/s12864-021-07632-z

Brandenburg, L.-O., Merres, J., Albrecht, L.-J., Varoga, D., and Pufe, T. (2012). Antimicrobial peptides: multifunctional drugs for different applications. *Polymers* 4, 539–560. doi: 10.3390/polym4010539

Britten, A. Z., and Smith, G. F. (1972). Autoxidation of 3,3′-dimethyl-2,2′-bi-indolyl. *J. Chem. Soc. Perkin Trans.* 1, 418–420. doi: 10.1039/P19720000418

Buback, M., and Kowollik, C. (1999). Termination kinetics in free-radical bulk copolymerization: the systems dodecyl acrylate−dodecyl methacrylate and dodecyl acrylate−methyl acrylate. *Macromolecules* 32, 1445–1452. doi: 10.1021/ma9814806

Campos, J. F., Besson, T., and Berteina-Raboin, S. (2022). Review on the synthesis and therapeutic potential of pyrido[2,3-d], [3,2-d], [3,4-d] and [4,3-d]pyrimidine derivatives. *Pharmaceuticals* 15:352. doi: 10.3390/ph15030352

Carballeira, N. M., Montano, N., Balaña-Fouce, R., and Prada, C. F. (2009). First total synthesis and antiprotozoal activity of (Z)-17-methyl-13-octadecenoic acid, a new marine fatty acid from the sponge *Polymastia penicillus*. *Chem. Phys. Lipids* 161, 38–43. doi: 10.1016/j.chemphyslip.2009.06.140

Carballeira, N. M., Montano, N., Vicente, J., and Rodriguez, A. D. (2007). Novel cyclopropane fatty acids from the phospholipids of the Caribbean sponge *Pseudospongosorites suberitoides*. *Lipids* 42, 519–524. doi: 10.1007/s11745-007-3047-3

Carrillo Perez, C., Del, C. C. M., and Alonso De La Torre, S. (2012). Antitumor effect of oleic acid; mechanisms of action. A review. *Nutr. Hosp.* 27, 1860–1865. doi: 10.3305/nh.2012.27.6.6010

Chagnes, A., Rager, M.-N., Courtaud, B., Thiry, J., and Cote, G. (2010). Speciation of vanadium (V) extracted from acidic sulfate media by trioctylamine in n-dodecane modified with 1-tridecanol. *Hydrometallurgy* 104, 20–24. doi: 10.1016/j.hydromet.2010.04.004

Chaler, R., Canton, L., Vaquero, M., and Grimalt, J. O. (2004). Identification and quantification of n-octyl esters of alkanoic and hexanedioic acids and phthalates as urban wastewater markers in biota and sediments from estuarine areas. *J. Chromatogr. A* 1046, 203–210.

Chater, K. F. (2006). Streptomyces inside-out: a new perspective on the bacteria that provide us with antibiotics. *Philos. Trans. R. Soc. Lond., B, Biol. Sci.* 361, 761–768. doi: 10.1098/rstb.2005.1758

Chater, K. F. (2013). "Streptomyces," in *Brenner's encyclopedia of genetics*. eds. S. Maloy and K. Hughes (Cambridge, Massachusetts, United States: Elsevier), 565–567.

Chen, D., Meng, Y., Zhu, Y., Wu, G., Yuan, J., Qin, M., et al. (2018). Qualitative and quantitative analysis of C-glycosyl-flavones of Iris lactea leaves by liquid chromatography/tandem mass spectrometry. *Molecules* 23:3359. doi: 10.3390/molecules23123359

Cho, J. H., Sung, B. H., and Kim, S. C. (2009). Buforins: histone H2A-derived antimicrobial peptides from toad stomach. *Biochim. Biophys. Acta Biomembr.* 1788, 1564–1569. doi: 10.1016/j.bbamem.2008.10.025

Choi, W. H., and Jiang, M. (2014). Evaluation of antibacterial activity of hexanedioic acid isolated from *Hermetia illucens* larvae. *J. Appl. Biomed.* 12, 179–189. doi: 10.1016/j.jab.2014.01.003

Chowdhury, S. K., Dutta, T., Chattopadhyay, A. P., Ghosh, N. N., Chowdhury, S., and Mandal, V. (2021). Isolation of antimicrobial tridecanoic acid from *Bacillus* sp. LBF-01 and its potentialization through silver nanoparticles synthesis: a combined experimental and theoretical studies. *J. Nanostruct. Chem.* 11, 573–587. doi: 10.1007/s40097-020-00385-3

Clark Mason, J., Richards, M., Zimmermann, W., and Broda, P. (1988). Identification of extracellular proteins from actinomycetes responsible for the solubilisation of lignocellulose. *Appl. Microbiol. Biotechnol.* 28, 276–280. doi: 10.1007/BF00250455

Cleary, J. L., Kolachina, S., Wolfe, B. E., and Sanchez, L. M. (2018). Coproporphyrin III produced by the bacterium *Glutamicibacter arilaitensis* binds zinc and is upregulated by fungi in cheese rinds. *mSystems* 3, e00036–e00018. doi: 10.1128/mSystems.00036-18

Collin, F., and Maxwell, A. (2019). The microbial toxin microcin B17: prospects for the development of new antibacterial agents. *J. Mol. Biol.* 431, 3400–3426. doi: 10.1016/j.jmb.2019.05.050

Cruciani, R. A., Barker, J. L., Zasloff, M., Chen, H. C., and Colamonici, O. (1991). Antibiotic magainins exert cytolytic activity against transformed cell lines through channel formation. *Proc. Natl. Acad. Sci. U. S. A.* 88, 3792–3796. doi: 10.1073/pnas.88.9.3792

Cullere, L., Cacho, J., and Ferreira, V. (2004). Analysis for wine C5–C8 aldehydes through the determination of their O-(2,3,4,5,6-pentafluorobenzyl)oximes formed directly in the solid phase extraction cartridge. *Anal. Chim. Acta* 524, 201–206. doi: 10.1016/j.aca.2004.03.025

Damiano, F., De Benedetto, G. E., Longo, S., Giannotti, L., Fico, D., Siculella, L., et al. (2020). Decanoic acid and not octanoic acid stimulates fatty acid synthesis in U87MG glioblastoma cells: a metabolomics study. *Front. Neurosci.* 14:783. doi: 10.3389/fnins.2020.00783

Daniels, A., and Temikotan, T. (2021). Fatty acid profile, antioxidant and antibacterial effect of the ethyl acatate extract of cleistopholis patens. *Bull. Sci. Res.* 3, 21–31. doi: 10.34256/bsr2113

Das, L., Deb, S., and Das, S. (2020). *Glutamicibacter mishrai* sp. nov., isolated from the coral *Favia veroni* from Andaman Sea. *Arch. Microbiol.* 202, 1–13. doi: 10.1007/s00203-019-01783-0

de Bony, J., Martin, G., Welby, M., and Tocanne, J. F. (1984). Evidence for a homogeneous lateral distribution of lipids in a bacterial membrane: a photo cross-linking approach using anthracene as a photoactivable group. *FEBS Lett.* 174, 1–6. doi: 10.1016/0014-5793(84)81065-0

Deb, S., Das, L., and Das, S. K. (2020). Phylogenomic analysis reveals that *Arthrobacter mysorens* Nand and Rao 1972 (approved lists 1980) and *Glutamicibacter mysorens* Busse 2016 are later heterotypic synonyms of *Arthrobacter nicotianae* Giovannozzi-Sermanni 1959 (approved lists 1980) and Glutamicibacter nicotianae Busse 2016. *Curr. Microbiol.* 77, 3793–3798. doi: 10.1007/s00284-020-02176-z

Deryabin, D. G., and Tolmacheva, A. A. (2015). Antibacterial and anti-quorum sensing molecular composition derived from Quercus cortex (oak bark) extract. *Molecules* 20, 17093–17108. doi: 10.3390/molecules200917093

Desouky, S. E., Shojima, A., Singh, R. P., Matsufuji, T., Igarashi, Y., Suzuki, T., et al. (2015). Cyclodepsipeptides produced by actinomycetes inhibit cyclic-peptide-mediated quorum sensing in Gram-positive bacteria. *FEMS Microbiol. Lett.* 362:fnv109. doi: 10.1093/femsle/fnv109

Desriac, F., Jegou, C., Balnois, E., Brillet, B., Chevalier, P. L., and Fleury, Y. (2013). Antimicrobial peptides from marine proteobacteria. *Mar. Drugs* 11, 3632–3660. doi: 10.3390/md11103632

Dhakal, R., Li, X., Parkin, S. R., and Lehmler, H.-J. (2020). Synthesis of mono- and dimethoxylated polychlorinated biphenyl derivatives starting from fluoroarene derivatives. *Environ. Sci. Pollut. Res. Int.* 27, 8905–8925. doi: 10.1007/s11356-019-07133-3

Djoussé, L., Matsumoto, C., Hanson, N. Q., Weir, N. L., Tsai, M. Y., and Gaziano, J. M. (2014). Plasma cis-vaccenic acid and risk of heart failure with antecedent coronary heart disease in male physicians. *Clin. Nutr.* 33, 478–482. doi: 10.1016/j.clnu.2013.07.001

Dulińska-Litewka, J., Gąsiorkiewicz, B., Litewka, A., Gil, D., Gołąbek, T., and Okoń, K. (2020). Could the kinetin riboside be used to inhibit human prostate cell epithelial–mesenchymal transition? *Med. Oncol.* 37:17. doi: 10.1007/s12032-020-1338-1

EL-Hashash, M. A., Essawy, A., and Sobhy Fawzy, A. (2014). Synthesis and antimicrobial activity of some novel heterocyclic candidates via Michael addition involving 4-(4-Acetamidophenyl)-4-oxobut-2-enoic acid. *Adv. Chem.* 2014:e619749, 1–10. doi: 10.1155/2014/619749

Es, B. (2014). Antibacterial potential of Luprops tristis - the nuisance rubber plantation Pest from Western Ghats of India. *IJAIR* 3

Ezekwe, S., Rizwan, A., Rabiu, K., and Ogbonnaya, E. (2020). Qualitative phytochemical and GC-MS analysis of some commonly consumed vegetables. *GSC Biol. Pharm. Sci.* 12, 208–214. doi: 10.30574/gscbps.2020.12.3.0299

Fadhil, L., Kadhim, S., and Hameed, I. (2018). Detection of bioactive secondary metabolites produced by *Bacillus subtilis* using gas chromatography-mass spectrometry technique. *Indian J. Public Health Res. Dev.* 9:1097. doi: 10.5958/0976-5506.2018.00877.X

Fahem, N., Djellouli, A. S., and Bahri, S. (2020). Cytotoxic activity assessment and GC-MS screening of two codium species extracts. *Pharm. Chem. J.* 54, 755–760. doi: 10.1007/s11094-020-02266-z

Fang, B.-Z., Salam, N., Han, M.-X., Jiao, J.-Y., Cheng, J., Wei, D.-Q., et al. (2017). Insights on the effects of heat pretreatment, pH, and calcium salts on isolation of rare actinobacteria from Karstic caves. *Front. Microbiol.* 8:1535. doi: 10.3389/fmicb.2017.01535

Fauzi, A., Jawad, M., and Hameed, I. (2017). Phytochemical profiles of methanolic seeds extract of Cuminum cyminum using GC-MS technique. *Int. J. Curr. Pharm. Rev. Res.* 8, 1–9. doi: 10.25258/ijcprr.v8i02.9194

Fernebro, J. (2011). Fighting bacterial infections-future treatment options. *Drug Resist. Updat.* 14, 125–139. doi: 10.1016/j.drup.2011.02.001

Francke, W., and Schulz, S. (1999). "8.04 - pheromones" in *Comprehensive natural products chemistry*. eds. S. D. Barton, K. Nakanishi and O. Meth-Cohn (Oxford: Pergamon), 197–261.

Fu, B., Olawole, O., and Beattie, G. A. (2021). Biological control and microbial ecology draft genome sequence data of *Glutamicibacter* sp. FBE-19, a bacterium antagonistic to the plant pathogen *Erwinia tracheiphila*. *Phytopathology* 111, 765–768. doi: 10.1094/PHYTO-09-20-0380-A

Fuentes, A. S., del Pozo Losada, C., and Vora, H. U. (2016). "(−)-(4R,5R)-4,5-Bis[hydroxy(diphenyl)methyl]-2,2-dimethyl-1,3-dioxolane" in *Encyclopedia of reagents for organic synthesis*. eds. A. Charette, J. Bode, T, Rovis, and R. Shenvi (Hoboken, New Jersey, United States: John Wiley & Sons, Ltd), 1–9.

Fukuda, K., and Kono, H. (2021). "Cost-benefit analysis and industrial potential of exopolysaccharides," in *Microbial exopolysaccharides as novel and significant biomaterials*. eds. A. K. Nadda, K. V. Sajna and S. Sharma (Cham: Springer), 303–339.

Gad, S. E. (2014). "Hydroperoxide, tert-Butyl" in *Encyclopedia of toxicology*. ed. P. Wexler. *Third* ed (Oxford: Academic Press), 977–978.

Gadhi, A., El-Sherbiny, M., Al-Sofynai, A., Baakdah, M., and Sathianeson, S. (2019). Antimicrofouling activities of marine macroalga Dictyota dichotoma from the Red Sea. *J. Agric. Mar. Sci.* 23:58. doi: 10.24200/jams.vol23iss0pp58-67

Ganyam, M., Anaduaka, E., Gabriel, F., Sani, S., and Fedilis, I. (2019). Effects of methanol extract of toasted african yam bean seeds (*Sphenostylis stenocarpa*) on anti-inflammatory properties. *Pharmacol. Online* 3, 100–113.

Gautam, V., Sharma, A., Arora, S., and Bhardwaj, R. (2016). Bioactive compounds in the different extracts of flowers of *Rhododendron arboreum Sm*. *J. Chem. Pharm. Res.* 2016, 439–444.

Gensler, W. J., and Thomas, G. R. (1952). Synthesis of unsaturated fatty acids: vaccenic acid. *J. Am. Chem. Soc.* 74, 3942–3943. doi: 10.1021/ja01135a511

Gil, S., Lázaro, M. A., Mestres, R., Millan, F., and Parra, M. (1995). Components of the sex pheromone of chilo supressalis: efficient syntheses of (Z)-11-hexadecenal and (Z)-13-Octadecenal. *Synth. Commun.* 25, 351–361. doi: 10.1080/00397919508011366

Godwin, J., Chukwu, U. J., and Gad, T. (2012). Distribution of iron (ii) between buffered aqueous solutions and chloroform solution of N, N'-ethylenebis(4-butanoyl-2,4-dihydro-5-methyl-2-phenyl-3h-pyrazol-3-oneimine). *J. Adv. Chem.* 8, 1581–1589. doi: 10.24297/jac.v8i2.4039

Gülerman, N., Oruç-Emre, E., Kartal, F., and Rollas, S. (2000). In vivo metabolism of 4-fluorobenzoic acid [(5-nitro-2-furanyl)methylene] hydrazide in rats. *Eur. J. Drug Metab. Pharmacokinet.* 25, 103–108. doi: 10.1007/BF03190075

Halling, P. J., Ross, A. C., and Bell, G. (1998). "Inactivation of enzymes at the aqueous-organic interface" in *Progress in biotechnology stability and stabilization of biocatalysts*. eds. A. Ballesteros, F. J. Plou, J. L. Iborra and P. J. Halling (Amsterdam, Netherlands: Elsevier), 365–372.

Ham, J. E., and Raymond Wells, J. (2009). Surface chemistry of dihydromyrcenol (2,6-dimethyl-7-octen-2-ol) with ozone on silanized glass, glass, and vinyl flooring tiles. *Atmos. Environ.* 43, 4023–4032. doi: 10.1016/j.atmosenv.2009.05.007

Hamalainen, T. I., Sundberg, S., Makinen, M., Kaltia, S., Hase, T., and Hopia, A. (2001). Hydroperoxide formation during autoxidation of conjugated linoleic acid methyl ester. *Eur. J. Lipid Sci. Technol.* 103, 588–593. doi: 10.1002/1438-9312(200109)103:9<588::AID-EJLT5880>3.0.CO;2-L

Hidri, R., Mahmoud, O. M.-B., Zorrig, W., Mahmoudi, H., Smaoui, A., Abdelly, C., et al. (2022). Plant growth-promoting rhizobacteria alleviate high salinity impact on the halophyte *Suaeda fruticosa* by modulating antioxidant defense and soil biological activity. *Front. Plant Sci.* 13:821475. doi: 10.3389/fpls.2022.821475

Holman, R. T., Deubig, M., and Hayes, H. (1966). Pyrolysis chromatography of lipids. I. Mass spectrometric identification of pyrolysis products of hydrocarbons. *Lipids* 1, 247–253. doi: 10.1007/BF02531610

Hoskin, D. W., and Ramamoorthy, A. (2008). Studies on anticancer activities of antimicrobial peptides. *Biochim. Biophys. Acta - Biomembr.* 1778, 357–375. doi: 10.1016/j.bbamem.2007.11.008

Hosseini Hashemi, S. K., Anooshei, H., Aghajani, H., and Salem, M. (2015). Chemical composition and antioxidant activity of extracts from the inner bark of *Berberis vulgaris* stem. *Bioresources* 10, 7958–7969. doi: 10.15376/biores.10.4.7958-7969

Hui, M. L.-Y., Tan, L. T.-H., Letchumanan, V., He, Y.-W., Fang, C.-M., Chan, K.-G., et al. (2021). The extremophilic actinobacteria: from microbes to medicine. *Antibiotics* 10:682. doi: 10.3390/antibiotics10060682

Hušek, P., Švagera, Z., Hanzlíková, D., Řimnáčová, L., Zahradníčková, H., Opekarová, I., et al. (2016). Profiling of urinary amino-carboxylic metabolites by in-situ heptafluorobutyl chloroformate mediated sample preparation and gas chromatography–mass spectrometry. *J. Chromatogr. A* 1443, 211–232. doi: 10.1016/j.chroma.2016.03.019

Hussein, A. O., Hameed, I. H., Jasim, H., and Kareem, M. A. (2015). Determination of alkaloid compounds of *Ricinus communis* by using gas chromatography- mass spectroscopy (GC-MS). *JMPR* 9, 349–359. doi: 10.5897/JMPR2015.5750

Hussein, J., Mohammed, Y. H., and Imad, H. H. (2016). Study of chemical composition of Foeniculum vulgare using Fourier transform infrared spectrophotometer and gas chromatography -mass spectrometry. *J. Pharmacogn. Phytother.* 8, 60–89. doi: 10.5897/JPP2015.0372

Ikhsanov, Y. S., Abilov Zh, A., Choudhary, M. I., and Sultanova, N. A. (2018). Study of the chemical composition of dichloromethane extract Tamarix hispida. Bulletin of the Karaganda University. Chemistry Series.

Ivankin, A. (2017). Biotechnology for formation of aromatic properties of National-Foodstuffs on the basis of meat raw material under influence of bacterial crops and Chromato-mass-spectrometric analysis of the flavoring components. *J. Appl. Biotechnol. Bioeng.* 3, 366–372. doi: 10.15406/jabb.2017.03.00072

Ivkin, D. Y., Luzhanin, V. G., Karpov, A. A., Minasyan, S. M., Poleshchenko, Y. I., Mamedov, A. E., et al. (2018). Embinin is a perspective cardiotonic mean for natural origin. *Drug Dev. Regist.* 0, 166–170.

Jachak, M., Bhusnar, A., Medhane, V., and Toche, R. (2006). A convenient route for the synthesis of pyrazolo[3,4-d]pyrimidine, pyrazolo[3,4-b][1,6]naphthyridine and pyrazolo[3,4-b]quinoline derivatives. *J. Heterocyclic Chem.* 43, 1169–1175. doi: 10.1002/jhet.5570430506

Jaffar, A., Somanath, B., and Karthi, S. (2015). Efficacy of methanolic extract of a marine ascidian, *Lissoclinum bistratum* for antimicrobial activity. *J. Chem. Biol. Phys. Sci.* 5:4119.

Jahan, I., Tona, M. R., Sharmin, S., Sayeed, M. A., Tania, F. Z., Paul, A., et al. (2020). GC-MS phytochemical profiling, pharmacological properties, and in Silico studies of *Chukrasia velutina* leaves: a novel source for bioactive agents. *Molecules* 25:3536. doi: 10.3390/molecules25153536

James, A. T., and Martin, A. J. P. (1956). Gas–liquid chromatography: the separation and identification of the methyl esters of saturated and unsaturated acids from formic acid to n-octadecanoic acid. *Biochem. J.* 63, 144–152. doi: 10.1042/bj0630144

Jamieson, S. M. F., Brooke, D. G., Heinrich, D., Atwell, G. J., Silva, S., Hamilton, E. J., et al. (2012). 3-(3,4-Dihydroisoquinolin-2(1H)-ylsulfonyl)benzoic acids: highly potent and selective inhibitors of the type 5 17-β-hydroxysteroid dehydrogenase AKR1C3. *J. Med. Chem.* 55, 7746–7758. doi: 10.1021/jm3007867

Janardhan, A., Kumar, A. P., Viswanath, B., Saigopal, D. V. R., and Narasimha, G. (2014). Production of bioactive compounds by actinomycetes and their antioxidant properties. *Biotechnol. Res. Int.* 2014, 1–9. doi: 10.1155/2014/217030

Janneck, R., Heremans, P., Genoe, J., and Rolin, C. (2018). Influence of the surface treatment on the solution coating of single-crystalline organic thin-films. *Adv. Mater. Interfaces* 5:1800147. doi: 10.1002/admi.201800147

Jawad, M., Mohammad, G., and Hussein, H. (2016). Analysis of bioactive metabolites from Candida albicans using (GC-MS) and evaluation of antibacterial activity 8, 655–670.

Jenkins, B., West, J. A., and Koulman, A. (2015). A review of odd-chain fatty acid metabolism and the role of pentadecanoic acid (C15:0) and heptadecanoic acid (C17:0) in health and disease. *Molecules* 20, 2425–2444. doi: 10.3390/molecules20022425

Jiang, J., and Jia, X. (2015). Profiling of fatty acids composition in suet oil based on GC–EI-qMS and chemometrics analysis. *Int. J. Mol. Sci.* 16, 2864–2878. doi: 10.3390/ijms16022864

Joshi, P. R., Paudel, M. R., Chand, M. B., Pradhan, S., Pant, K. K., Joshi, G. P., et al. (2020). Cytotoxic effect of selected wild orchids on two different human cancer cell lines. *Heliyon* 6:e03991. doi: 10.1016/j.heliyon.2020.e03991

Jubete, G., Puig de la Bellacasa, R., Estrada-Tejedor, R., Teixidó, J., and Borrell, J. I. (2019). Pyrido[2,3-d]pyrimidin-7(8H)-ones: synthesis and biomedical applications. *Molecules* 24:4161. doi: 10.3390/molecules24224161

Juturu, V., and Wu, J. C. (2018). Microbial production of bacteriocins: latest research development and applications. *Biotechnol. Adv.* 36, 2187–2200. doi: 10.1016/j.biotechadv.2018.10.007

Karthik, Y., and Kalyani, M. I. (2021). Molecular profiling of Glutamicibacter Mysorens strain YKIKM.MU and bioactive peptides characterization for antibacterial activity. *Int. J. Pharm. Clin. Res.* 13:15.

Karthik, Y., and Kalyani, M. I. (2022). Occurrence of Streptomyces tauricus in mangrove soil of Mangalore region in Dakshina Kannada as a source for antimicrobial peptide. *J. Basic Microbiol.* 62, 1–15. doi: 10.1002/jobm.202200108

Karthik, Y., Kalyani, M. I., Sheetal, K., Rakshitha, D., and Bineesha, B. K. (2020). Cytotoxic and antimicrobial activities of microbial proteins from mangrove soil actinomycetes of Mangalore, Dakshina Kannada. *Biomedicine* 40, 59–67. doi: 10.51248/.v40i1.104

Kaur, S., Sharma, P., Bains, A., Chawla, P., Sridhar, K., Sharma, M., et al. (2022). Antimicrobial and anti-inflammatory activity of low-energy assisted nanohydrogel of *Azadirachta indica* oil. *Gels* 8:434. doi: 10.3390/gels8070434

Kawase, A., and Yagishita, K. (1968). On the structure of a new C-glycosyl flavone, embinin, isolated from the petals of Iris germanica Linnaeous*1. *Agric. Biol. Chem.* 32, 537–538. doi: 10.1080/00021369.1968.10859095

Khadayat, K., Sherpa, D. D., Malla, K. P., Shrestha, S., Rana, N., Marasini, B. P., et al. (2020). Molecular identification and antimicrobial potential of *Streptomyces* species from nepalese soil. *Int. J. Microbiol.* 2020:e8817467. doi: 10.1155/2020/8817467

Khidre, R., Abuhashem, A., and El-Shazly, M. (2011). Synthesis and anti-microbial activity of some 1-substituted amino-4, 6-dimethyl-2-oxo-pyridine-3-carbonitrile derivatives. *Eur. J. Med. Chem.* 46, 5057–5064. doi: 10.1016/j.ejmech.2011.08.018

Khodaei, M., and Sh, S. N. (2018). Isolation and molecular identification of Bacteriocin-producing enterococci with broad antibacterial activity from traditional dairy products in Kerman Province of Iran. *Korean J. Food Sci. Anim. Resour.* 38, 172–179. doi: 10.5851/kosfa.2018.38.1.172

Khusro, A., Aarti, C., and Agastian, P. (2020). Microwave irradiation-based synthesis of anisotropic gold nanoplates using *Staphylococcus hominis* as reductant and its optimization for therapeutic applications. *J. Environ. Chem. Eng.* 8:104526. doi: 10.1016/j.jece.2020.104526

Kratky, M., Konečná, K., Janoušek, J., Brablíková, M., Janďourek, O., Trejtnar, F., et al. (2019). 4-Aminobenzoic acid derivatives: converting folate precursor to antimicrobial and cytotoxic agents. *Biomol. Ther.* 10:9. doi: 10.3390/biom10010009

Kroumova, A. B., and Wagner, G. J. (2003). Different elongation pathways in the biosynthesis of acyl groups of trichome exudate sugar esters from various solanaceous plants. *Planta* 216, 1013–1021. doi: 10.1007/s00425-002-0954-7

Kula, J., Quang, T. B., and Smigielski, K. (2001). Convenient synthesis of (r)-1,3-nonanediol. *Synth. Commun.* 31, 463–467. doi: 10.1081/SCC-100000540

Kurnianto, M. A., Kusumaningrum, H. D., Lioe, H. N., and Chasanah, E. (2021). Partial purification and characterization of bacteriocin-like inhibitory substances produced by *Streptomyces* sp. isolated from the gut of Chanos chanos. *Biomed. Res. Int.* 2021:7190152. doi: 10.1155/2021/7190152

Lemieux, R. U., and Nagabhushan, T. L. (1968). The synthesis of 2-amino-2-deoxyhexoses: D-glucosamine, D-mannosamine, D-galactosamine, and D-talosamine. *Can. J. Chem.* 46, 401–403. doi: 10.1139/v68-064

Ley, S. V., and Madin, A. (1991). "2.7 - oxidation adjacent to oxygen of alcohols by chromium reagents" in *Comprehensive organic synthesis*. eds. B. M. Trost and I. Fleming (Oxford: Pergamon), 251–289.

Li, H., Liu, X., and Fang, G. (2010). Preparation and characteristics of n-nonadecane/cement composites as thermal energy storage materials in buildings. *Energ. Buildings* 42, 1661–1665. doi: 10.1016/j.enbuild.2010.04.009

MacKenzie, S. L., and Tenaschuk, D. (1979). Quantitative fromation of N(O,S)-heptafluorobutyryl isobutyl amino acids for gas chromatographic analysis: I. Esterification. *J. Chromatogr. A* 171, 195–208. doi: 10.1016/S0021-9673(01)95299-9

Martín-Acosta, P., Amesty, A., Guerra-Rodríguez, M., Guerra, B., Fernández-Pérez, L., and Estévez-Braun, A. (2021). Modular synthesis and antiproliferative activity of new dihydro-1H-pyrazolo[1,3-b]pyridine embelin derivatives. *Pharmaceuticals (Basel)* 14:1026. doi: 10.3390/ph14101026

Martinez, C., Hu, S., Dumond, Y., Tao, J., Kelleher, P., and Tully, L. (2008). Development of a Chemoenzymatic manufacturing process for pregabalin. *Org. Process Res. Dev.* 12, 392–398. doi: 10.1021/op7002248

Matthew, O., James, A., Akogwu, I., Fabunmi, T., Godwin, I., Ebun, B., et al. (2022). The reference colored blue in the reference section should be cited in the body of the work evaluation of in vitro antioxidant, phytochemical and Gc- Ms analysis of aqueous extract of Solanum Dasyphyllum fruits.

McCarthy, E. D., and Calvin, M. (1967). The isolation and identification of the C17 saturated isoprenoid hydrocarbon 2,6,10-trimethyltetradecane from a Devonian shale: the role of squalane as a possible precursor. *Tetrahedron* 23, 2609–2619. doi: 10.1016/0040-4020(67)85125-1

Mihooliya, K. N., Nandal, J., Swami, L., Verma, H., Chopra, L., and Sahoo, D. K. (2017). A new pH indicator dye-based method for rapid and efficient screening of l-asparaginase producing microorganisms. *Enzym. Microb. Technol.* 107, 72–81. doi: 10.1016/j.enzmictec.2017.08.004

Millero, F. J., Graham, T. B., Huang, F., Bustos-Serrano, H., and Pierrot, D. (2006). Dissociation constants of carbonic acid in seawater as a function of salinity and temperature. *Mar. Chem.* 100, 80–94. doi: 10.1016/j.marchem.2005.12.001

Ming Miao, Y., and Zhi, Y. (2018). Mass spectrum of acids, alcohols, esters and amines of coffee hull (Typical.Arabica).

Mohan, Y., Sirisha, B., Haritha, R., and Ramana, T. (2013). Selective screening, isolation and characterization of antimicrobial agents from marine actinomycetes. *Int J Pharm Pharm Sci* 5, 443–449.

Moldoveanu, S. C. (2019). "Chapter 2 - pyrolysis of hydrocarbons," in *Pyrolysis of organic molecules*. ed. S. C. Moldoveanu. *Second* ed (Amsterdam, Netherlands: Elsevier), 35–161.

Narra, N., Kaki, S. S., Badari, R., Prasad, R. B. N., Misra, S., Koude, D., et al. (2017). Synthesis and evaluation of anti-oxidant and cytotoxic activities of novel 10-undecenoic acid methyl ester based lipoconjugates of phenolic acids. *Beilstein J. Org. Chem.* 2017, 26–32. doi: 10.3762/bjoc.13.4

Nishioka, K., and Katayama, I. (1978). Angiogenic activity in culture supernatant of antigen-stimulated lymph node cells. *J. Pathol.* 126, 63–69. doi: 10.1002/path.1711260202

Onocha, A., Abimbade, S., and Oloyede, G. (2011). Chemical composition, toxicity, antimicrobial and antioxidant activities of leaf and stem essential oils of *Dieffenbachia picta* (Araceae). *Eur. J. Sci. Res.* 49, 567–580.

Osgerby, L., Lai, Y.-C., Thornton, P. J., Amalfitano, J., Le Duff, C. S., Jabeen, I., et al. (2017). Kinetin riboside and its ProTides activate the Parkinson's disease associated PTEN-induced putative kinase 1 (PINK1) independent of mitochondrial depolarization. *J. Med. Chem.* 60, 3518–3524. doi: 10.1021/acs.jmedchem.6b01897

Ozden, S., Oztürk, A., Goker, H., and Altanlar, N. (2000). Synthesis and antimicrobial activity of some new 4-hydroxy-2H-1,4-benzoxazin-3(4H)-ones. *Farmaco* 55, 715–718. doi: 10.1016/S0014-827X(00)00098-7

Palanki, M., Erdman, P. E., Goldman, M. E., Suto, C., and Suto, M. J. (2000). Synthesis and structure-activity relationship studies of conformationally restricted, analogs of 2-chloro-4-trifluoromethylpyrimidine- 5-[N-(3′,5′-bis(trifluoromethyl)phenyl)] carboxamide. *Med. Chem. Res.* 10, 19–29.

Patel, K., Piagentini, M., Rascher, A., Tian, Z.-Q., Buchanan, G. O., Regentin, R., et al. (2004). Engineered biosynthesis of geldanamycin analogs for Hsp90 inhibition. *Chem. Biol.* 11, 1625–1633. doi: 10.1016/j.chembiol.2004.09.012

Phuong, T. V., and Diep, C. N. (2020). Isolation and selection of actinobacteria against pathogenic bacteria from shrimp pond water on Duyen Hai District, Tra Vinh Province, Vietnam. *Int. J. Environ. Agric. Res.* 6:8.

Qin, S., Feng, W.-W., Zhang, Y.-J., Wang, T.-T., Xiong, Y.-W., and Xing, K. (2018). Diversity of bacterial microbiota of coastal halophyte *Limonium sinense* and amelioration of salinity stress damage by symbiotic plant growth-promoting actinobacterium *Glutamicibacter halophytocola* KLBMP 5180. *Appl. Environ. Microbiol.* 84, e01533–e01518. doi: 10.1128/AEM.01533-18

Qiu, H., Liu, R., and Long, L. (2019). Analysis of chemical composition of extractives by acetone and the chromatic aberration of teak (Tectona Grandis L.F.) from China. *Molecules* 24, 1–10. doi: 10.3390/molecules24101989.

Qiu, D., Meng, H., Jin, L., Wang, S., Tang, S., Wang, X., et al. (2013). ChemInform abstract: synthesis of aryl trimethylstannanes from aryl amines: a sandmeyer-type stannylation reaction. *Angew. Chem. Int. Ed. Eng.* 125, 11581–11584. doi: 10.1002/anie.201304579

Ransom, C., Grey, T., Howatt, K., Johnson, E., Keese, R., Nurse, R., et al. (2012). Common and chemical names of herbicides approved by the weed science Society of America. *Weed Sci.* 60, 650–657.

Rebbert, R. E., and Ausloos, P. (1962). Intramolecular rearrangements in the solid phase photolysis of 4-methyl-2-hexanone and sec-butyl acetate. *J. Chem. Phys.* 37, 1158–1159. doi: 10.1063/1.1733239

Reddy, N., and Ananthaprasad, M. G. (2021). "Chapter 11 - polymeric materials for three-dimensional printing" in *Additive manufacturing Woodhead publishing reviews: Mechanical engineering series*. eds. M. Manjaiah, K. Raghavendra, N. Balashanmugam and J. P. Davim (Darya Ganj, Delhi, India: Woodhead Publishing), 233–274.

Renner, M. K., Shen, Y.-C., Cheng, X.-C., Jensen, P. R., Frankmoelle, W., Kauffman, C. A., et al. (1999). Cyclomarins a–C, new antiinflammatory cyclic peptides produced by a marine bacterium (*Streptomyces* sp.). *J. Am. Chem. Soc.* 121, 11273–11276. doi: 10.1021/ja992482o

Reza, A. S. M. A., Haque, M. A., Sarker, J., Nasrin Mst, S., Rahman, M. M., Tareq, A. M., et al. (2021). Antiproliferative and antioxidant potentials of bioactive edible vegetable fraction of *Achyranthes ferruginea* Roxb. In cancer cell line. *Food Sci. Nutr.* 9, 3777–3805. doi: 10.1002/fsn3.2343

Rossi, A., Martins, M. P., Bitencourt, T. A., Peres, N. T. A., Rocha, C. H. L., Rocha, F. M. G., et al. (2021). Reassessing the use of undecanoic acid as a therapeutic strategy for treating fungal infections. *Mycopathologia* 186, 327–340. doi: 10.1007/s11046-021-00550-4

Salem, M. Z. M., Zayed, M. Z., Ali, H. M., and Abd El-Kareem, M. S. M. (2016). Chemical composition, antioxidant and antibacterial activities of extracts from *Schinus molle* wood branch growing in Egypt. *J. Wood Sci.* 62, 548–561. doi: 10.1007/s10086-016-1583-2

Santos, R. G., Hurtado, R., Gomes, L. G. R., Profeta, R., Rifici, C., Attili, A. R., et al. (2020). Complete genome analysis of *Glutamicibacter creatinolyticus* from mare abscess and comparative genomics provide insight of diversity and adaptation for Glutamicibacter. *Gene* 741:144566. doi: 10.1016/j.gene.2020.144566

Sapkota, A., Thapa, A., Budhathoki, A., Sainju, M., Shrestha, P., and Aryal, S. (2020). Isolation, characterization, and screening of antimicrobial-producing actinomycetes from soil samples. *Int. J. Microbiol.* 2020, 1–7. doi: 10.1155/2020/2716584

Satgé, J., Massol, M., and Rivière, P. (1973). Divalent germanium species as starting materials and intermediates in organo germanium chemistry. *J. Organomet. Chem.* 56, 1–39. doi: 10.1016/S0022-328X(00)89951-9

Saxena, D., and Stotzky, G. (2001). Bacillus thuringiensis (Bt) toxin released from root exudates and biomass of Bt corn has no apparent effect on earthworms, nematodes, protozoa, bacteria, and fungi in soil. *Soil Biol. Biochem.* 33, 1225–1230. doi: 10.1016/S0038-0717(01)00027-X

Schwabe, A. D., Bennett, L. R., and Bowman, L. P. (1964). Octanoic acid absorption and oxidation in humans. *J. Appl. Physiol.* 19, 335–337. doi: 10.1152/jappl.1964.19.2.335

Senarath, S., Yoshinaga, K., Nagai, T., Yoshida, A., Beppu, F., and Gotoh, N. (2018). Differential effect of cis-eicosenoic acid positional isomers on adipogenesis and lipid accumulation in 3T3-L1 cells. *Eur. J. Lipid Sci. Technol.* 120:1700512. doi: 10.1002/ejlt.201700512

Ser, H. L., Palanisamy, U., Yin, W.-F., Abd Malek, N., Chan, K.-G., Goh, B. H., et al. (2015). Presence of antioxidative agent, pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro- in newly isolated *Streptomyces mangrovisoli* sp. nov. *Front. Microbiol.* 6:854. doi: 10.3389/fmicb.2015.00854

Shalini, K., Sharma, P. K., and Kumar, N. (2010). Imidazole and its biological activities: a review 13, 36–47.

Shawky, A. M., Ibrahim, N. A., Abdalla, A. N., Abourehab, M. A. S., and Gouda, A. M. (2021). Novel pyrrolizines bearing 3,4,5-trimethoxyphenyl moiety: design, synthesis, molecular docking, and biological evaluation as potential multi-target cytotoxic agents. *J. Enzyme Inhib. Med. Chem.* 36, 1312–1332. doi: 10.1080/14756366.2021.1937618

Silva, M. J., Samandar, E., Ye, X., and Calafat, A. M. (2013). In vitro metabolites of Di-2-ethylhexyl adipate (DEHA) as biomarkers of exposure in human biomonitoring applications. *Chem. Res. Toxicol.* 26, 1498–1502. doi: 10.1021/tx400215z

Simon, A., and Losada, C. (2008). (−)-(4 R,5 R)-4,5-Bis[hydroxy(diphenyl)methyl]-2,2-dimethyl-1,3-dioxolane.

Sivaprakash, S., Prakash, S., Mohan, S., and Jose, S. P. (2019). Quantum chemical studies and spectroscopic investigations on 2-amino-3-methyl-5-nitropyridine by density functional theory. *Heliyon* 5:e02149. doi: 10.1016/j.heliyon.2019.e02149

Skhirtladze, L., Leitonas, K., Bucinskas, A., Volyniuk, D., Mahmoudi, M., Mukbaniani, O., et al. (2022). 1,4-Bis(trifluoromethyl)benzene as a new acceptor for the design and synthesis of emitters exhibiting efficient thermally activated delayed fluorescence and electroluminescence: experimental and computational guiding. *J. Mater. Chem. C* 10, 4929–4940. doi: 10.1039/D1TC05420A

Soleha, M., Pratiwi, D., Sari, I., Hermiyanti, E., Yunarto, N., and Setyorini, H. (2020). Antioxidant activity of methanol extract *Tetracera scanden* L Merr predicted active compound of methanol extract with GCMS NIST library. *J. Phys. Conf. Ser.* 1665:012028. doi: 10.1088/1742-6596/1665/1/012028

Sridevi, V., Priyadarshini, P. S., and Gautam, Y. A. (2015). Selection of marine actinomycetes with bioactive potential isolated from sediments of Bay of Bengal and characterization of promising isolate, ABT-103. *Microbiol. Res. J. Int.* 10, 1–9. doi: 10.9734/BMRJ/2015/20132

Sridhar, K., Bhargavan, R., and Kasinathan, S. (2016). Phytochemical screening and gc-ms analysis of ethanolic extract of *Tribulus terrestris*. *Int. J. Pharmacol. Res.* 6, 44–50.

Srivastava, R., Mukerjee, A., and Verma, A. (2015). GC-MS analysis of Phytocomponents in, pet ether fraction of *Wrightia tinctoria* seed. *Pharm. J.* 7, 249–253. doi: 10.5530/pj.2015.4.7

Su, X., Halem, H. A., Thomas, M. P., Moutrille, C., Culler, M. D., Vicker, N., et al. (2012). Adamantyl carboxamides and acetamides as potent human 11β-hydroxysteroid dehydrogenase type 1 inhibitors. *Bioorg. Med. Chem.* 20, 6394–6402. doi: 10.1016/j.bmc.2012.08.056

Sugrue, I., O'Connor, P. M., Hill, C., Stanton, C., and Ross, R. P. (2019). Actinomyces produces defensin-like bacteriocins (Actifensins) with a highly degenerate structure and broad antimicrobial activity. *J. Bacteriol.* 202, 1–15. doi: 10.1128/JB.00529-19

Takigawa, H., Nakagawa, H., Kuzukawa, M., Mori, H., and Imokawa, G. (2005). Deficient production of hexadecenoic acid in the skin is associated in part with the vulnerability of atopic dermatitis patients to colonization by *Staphylococcus aureus*. *DRM* 211, 240–248. doi: 10.1159/000087018

Talley, J. J., Bertenshaw, S. R., Brown, D. L., Carter, J. S., Graneto, M. J., Kellogg, M. S., et al. (2000). N-[[(5-methyl-3-phenylisoxazol-4-yl)- phenyl]sulfonyl]propanamide, sodium salt, parecoxib sodium: a potent and selective inhibitor of COX-2 for parenteral administration. *J. Med. Chem.* 43, 1661–1663. doi: 10.1021/jm000069h

Tanak, H., Karataş, Ş., Meral, S., and Agar, A. A. (2020). Synthesis, molecular structure and quantum chemical studies of N-(2-fluorophenyl)-1-(5-nitrothiophen-2-yl) methanimine. *Crystallogr. Rep.* 65, 1212–1216. doi: 10.1134/S106377452007024X

Tanaka, T., and Hayashi, M. (2008). Catalytic enantioselective reformatsky reaction of alkyl iodoacetate with aldehydes catalyzed by chiral Schiff Base. *Chem. Lett.* 37, 1298–1299. doi: 10.1246/cl.2008.1298

Tang, W., Meng, Z., Li, N., Liu, Y., Li, L., Chen, D., et al. (2021). Roles of gut microbiota in the regulation of hippocampal plasticity, inflammation, and hippocampus-dependent behaviors. *Front. Cell. Infect. Microbiol.* 10, 1–15. doi: 10.3389/fcimb.2020.611014

Thakor, P., Mehta, J. B., Patel, R. R., Patel, D. D., Subramanian, R. B., and Thakkar, V. R. (2016). Extraction and purification of phytol from *Abutilon indicum*: cytotoxic and apoptotic activity. *RSC Adv.* 6, 48336–48345. doi: 10.1039/C5RA24464A

Tsunoda, H., Kudo, T., Masaki, Y., Ohkubo, A., Seio, K., and Sekine, M. (2011). Biochemical behavior of N-oxidized cytosine and adenine bases in DNA polymerase-mediated primer extension reactions. *Nucleic Acids Res.* 39, 2995–3004. doi: 10.1093/nar/gkq914

Upgade, A., and Bhaskar, A. (2013). Characterization and medicinal importance of phytoconstituents of *C. Papaya* from down south Indian region using gas chromatography and mass spectroscopy. *Asian J. Pharm. Clin. Res.* 6, 101–106.

Van der Steen, M., and Stevens, C. V. (2009). Undecylenic acid: a valuable and physiologically active renewable building block from castor oil. *ChemSusChem* 2, 692–713. doi: 10.1002/cssc.200900075

Viegas, C. A., Rosa, M. F., Sa-Correia, I., and Novais, J. M. (1989). Inhibition of yeast growth by octanoic and decanoic acids produced during ETHANOLIC fermentation. *Appl. Environ. Microbiol.* 55, 21–28. doi: 10.1128/aem.55.1.21-28.1989

Wang, C., Lu, Y., and Cao, S. (2020). Antimicrobial compounds from marine actinomycetes. *Arch. Pharm. Res.* 43, 677–704. doi: 10.1007/s12272-020-01251-0

Wang, X., Shen, S., Wu, H., Wang, H., Wang, L., and Lu, Z. (2021). *Acinetobacter tandoii* ZM06 assists *Glutamicibacter nicotianae* ZM05 in resisting cadmium pressure to preserve dipropyl phthalate biodegradation. *Microorganisms* 9:1417. doi: 10.3390/microorganisms9071417

Wang, Y., Su, X., Liu, J., Fang, W., and Zhu, L. (2022). Complete genome sequence of *Glutamicibacter mysorens* NBNZ-009, isolated from Jin Lake sediment. *Microbiol. Resour. Announc.* 0, e00762–e00722. doi: 10.1128/mra.00762-22

Wang, W., Xiao, G., Du, G., Chang, L., Yang, Y., Ye, J., et al. (2022). Glutamicibacter halophytocola-mediated host fitness of potato tuber moth on *Solanaceae* crops. *Pest Manag. Sci.* 78, 3920–3930. doi: 10.1002/ps.6955

Wang, Y., Zhang, L.-T., Feng, Y.-X., Guo, S.-S., Pang, X., Zhang, D., et al. (2019). Insecticidal and repellent efficacy against stored-product insects of oxygenated monoterpenes and 2-dodecanone of the essential oil from *Zanthoxylum planispinum* var. dintanensis. *Environ. Sci. Pollut. Res.* 26, 24988–24997. doi: 10.1007/s11356-019-05765-z

Watanabe, M., Koike, H., Ishiba, T., Okada, T., Seo, S., and Hirai, K. (1997). Synthesis and biological activity of methanesulfonamide pyrimidine- and N-methanesulfonyl pyrrole-substituted 3,5-dihydroxy-6-heptenoates, a novel series of HMG-CoA reductase inhibitors. *Bioorg. Med. Chem.* 5, 437–444. doi: 10.1016/S0968-0896(96)00248-9

Williams, J. D., Torhan, M. C., Neelagiri, V., Brown, C., Bowlin, N. O., Di, M., et al. (2015). Synthesis and structure-activity relationships of novel phenoxyacetamide inhibitors of the Pseudomonas aeruginosa type III secretion system (T3SS). *Bioorg. Med. Chem.* 23, 1027–1043. doi: 10.1016/j.bmc.2015.01.011

Windey, K., De Preter, V., Louat, T., Schuit, F., Herman, J., Vansant, G., et al. (2012). Modulation of protein fermentation does not affect fecal water toxicity: a randomized cross-over study in healthy subjects. *PLoS One* 7:e52387. doi: 10.1371/journal.pone.0052387

Xie, F.-M., Li, H.-Z., Dai, G.-L., Li, Y.-Q., Cheng, T., Xie, M., et al. (2019). Rational molecular design of dibenzo[a,c]phenazine-based thermally activated delayed fluorescence emitters for orange-red OLEDs with EQE up to 22.0%. *ACS Appl. Mater. Interfaces* 11, 26144–26151. doi: 10.1021/acsami.9b06401

Xiong, Y.-W., Ju, X.-Y., Li, X.-W., Gong, Y., Xu, M.-J., Zhang, C.-M., et al. (2020). Fermentation conditions optimization, purification, and antioxidant activity of exopolysaccharides obtained from the plant growth-promoting endophytic actinobacterium *Glutamicibacter halophytocola* KLBMP 5180. *Int. J. Biol. Macromol.* 153, 1176–1185. doi: 10.1016/j.ijbiomac.2019.10.247

Xu, Y., Li, H., Li, X., Xiao, X., and Qian, P.-Y. (2008). Inhibitory effects of a branched-chain fatty acid on larval settlement of the polychaete hydroides elegans. *Mar. Biotechnol.* 11, 495–504. doi: 10.1007/s10126-008-9161-2

Xue, J., Zhuo, J., Liu, M., Chi, Y., Zhang, D., and Yao, Q. (2017). Synergetic effect of co-pyrolysis of cellulose and polypropylene over an all-silica mesoporous catalyst MCM-41 using Thermogravimetry–Fourier transform infrared spectroscopy and pyrolysis–gas chromatography–mass spectrometry. *Energy Fuel* 31, 9576–9584. doi: 10.1021/acs.energyfuels.7b01651

Yamamoto, T. (2002). Chlorination of bisphenol a in aqueous media: formation of chlorinated bisphenol a congeners and degradation to chlorinated phenolic compounds. *Chemosphere* 46, 1215–1223. doi: 10.1016/S0045-6535(01)00198-9

Zagulyaeva, A. A., Yusubov, M. S., and Zhdankin, V. V. (2010). A general and convenient preparation of [bis(trifluoroacetoxy)iodo]perfluoroalkanes and [bis(trifluoroacetoxy)iodo] arenes by oxidation of organic iodides using oxone and trifluoroacetic acid. *J. Organomet. Chem.* 75, 2119–2122. doi: 10.1021/jo902733f

Zeitoun, M., Adel, M., Abulfotouh, F., and Ebrahim, S. (2021). Thermophysical properties enhancement of octadecane using reduced graphene oxide and graphene oxide nanoplatelets. *J. Energy Storage* 38:102512. doi: 10.1016/j.est.2021.102512

Zhang, D., Lu, Y., Chen, H., Wu, C., Zhang, H., Chen, L., et al. (2020). Antifungal peptides produced by actinomycetes and their biological activities against plant diseases. *J. Antibiot.* 73, 265–282. doi: 10.1038/s41429-020-0287-4

Zhang, L., Peng, X.-M., Damu, G. L. V., Geng, R.-X., and Zhou, C.-H. (2014). Comprehensive review in current developments of imidazole-based medicinal chemistry. *Med. Res. Rev.* 34, 340–437. doi: 10.1002/med.21290

Zhang, X., Wang, Y.-X., Zhao, J., Duan, P., Chen, Y., and Chen, L. (2017). Structural insights into 9-Styrylanthracene-based luminophores: geometry control versus mechanofluorochromism and sensing properties. *Chem. Asian J.* 12, 830–834. doi: 10.1002/asia.201700183

Zibuck, R. (2001). "2-Acetoxyisobutyryl chloride" in *Encyclopedia of reagents for organic synthesis*. eds. A. Charette, J. Bode, T. Rovis, and R. Shenvi (Hoboken, New Jersey, United States: John Wiley & Sons, Ltd)