iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VI **Month of publication:** June 2019

DOI: http://doi.org/10.22214/ijraset.2019.6009

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VI, Jun2019- Available at www.ijraset.com

Industrial Products from Halophiles: A Review

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Abstract: Halophiles are microorganisms living in conditions with increased levels of Sodium chloride. The members of halophiles belong to the categories of Bacteria, Archaea and Eukarya. Since they live in a stressful environment their products possess more stability and activity compared to those obtained from inhabitants of normal environment. They are recently explored for a number of industrially important products like compatible solutes, enzymes, biopolymers, nutraceuticals, halocin and other important proteins. They have also found application in processes like biodegradation and bioremediation. Halocins include a number of antimicrobial substances obtained from halophiles. These are peptide or protein antibiotics that have either narrow or broad spectrum of activity against other microorganisms. Since the available antibiotics are failing due to resistance developed by infectious microorganisms, finding out new antibiotics from an unexplored or least explored environment is the best possible solution available. Hence halocins could be a useful target to explore further in this regard. This review presents a summary of information about the halophiles, industrially relevant products explored from halophiles and also depicts the future prospects in exploring halophiles for halocin production.
Keywords: halophiles, biopolymers, ectoine, archaea, biodegradation, halocin

I. INTRODUCTION

The role of halophiles in bioprocess industries has become inevitable for a number of reasons. They are proving successful in overcoming the limitations of bioprocesses involving conventional bacteria. The major issues reported in fermentation industry include high substrate cost, high processing cost and risk of contamination by undesirable organisms [1], [2], [3], [4]. Halophiles can utilize low cost substrates like agro-industrial wastes and do not require pre-treatment of substrates which can directly influence the process cost. Also they survive in extreme salt concentration in which other conventional bacteria cannot grow and contaminate.

II. HALOTOLERANTS AND HALOPHILES

Halotolerants are a group of microorganisms which does not require higher concentration of NaCl (>0.1M) for their growth but can tolerate their presence [5]. Halophiles are salt lovers and thrive only in conditions of slight, moderate and extreme NaCl concentrations. Hypersaline regions are predominant with moderate and extreme halophiles which can live up to 5M NaCl [6]. The intrinsic mechanisms available in such microbes like accumulation of osmolytes [7], [8], [9] or organic solutes like amino acids and sugars in cytoplasm make them survive in extreme environment [10], [11]. They predominantly accumulate equal concentration of K^+ in the intracellular environment to prevent the osmotic pressure. The taxonomy of halophiles covers both the prokaryotic and eukaryotic domains [12], [13], [14], [15]. Halophilic archaea are grow in extreme concentration (> 3M) of NaCl and are revealed to be different from conventional prokaryotes. They are rich in GC content and possess information related to survival in extreme environment [16].

III. FERMENTATION PRODUCTS FROM HALOPHILES

A variety of fermentation products are obtained from halophiles with cheap substrates and simple process parameters. Table 1 shows the representative products from halophiles isolated from different geographical locations. In majority of the process, the stability and activity of were also studied and found to be higher [17], [18], [19], [20], [21], [22], [23], [24].

TABLE1: Representative Fermentation Products From Halophiles

S.No.	Name of the halophile	Name of the fermentation product	Reference(s)
1.	*Halomonas* sp. AAD6	Exopolysaccharide	[25]
2.	*Halomonas boliviensis*	Ectoine and poly (3-hydroxybutyrate)	[26]
3.	*Halomonas boliviensis LC1*	Poly (β-hydroxybutyrate)	[27]
4.	*Halomonas TD01*	Polyhydroxybutyrate	[28]
5.	*Pseudomonas AP-MSU 2*	Phytase	[29]

6.	*Salicola sp. IC10*	Lipase and protease	[30]
7.	*Halobacillus karajensis, Halobiforma sp.strain BNMIITR*	Protease	[31], [32]
8.	*Halomonas meridiana*	α-amylase	[33]
9.	*Streptomonospora sp. YIM 90494*	xylanase	[34]
10.	*Marinococcus M52*	hydroxyectoine	[35]
11.	*Halorubrum sp. TBZ112*	Carotenoid	[36]
12.	*Halomonas sp. BS4*	Biosurfactant	[37]

IV. ANTIBIOTICS RESISTANCE: THE CHALLENGE

Resistance is defined as the ability of the infectious microorganisms to evade the mechanism of action of the antibiotics. Resistance was due to the repeated exposure of the antibiotics to the infectious microorganism [38]. The unregulated usage of antibiotics by the patients themselves is found to be the major reason lying behind this great issue [39]. The transfer of genetic materials through plasmids and transposons are also claimed to be the reasons for resistance development [40], [41], [42], [43]. Resistant microbes are available for almost all known classes of commercial antibiotics [44]. The problem has grown to a huge strength and now multidrug resistant microorganisms are the biggest challenge to be treated [45], [46]. The pharmaceutical industries are working at an alarming rate to get out of this problem but the entire process is limited by a series of challenges like inability of the synthetic or semi synthetic compounds to penetrate the cell wall, failure to adopt drug likeliness properties as proposed by Lipinski, the inherent toxicity of newly developed compounds and majorly the low returns on investment [39], [47]. Rather than looking for synthetic compound that shows activity against a infectious microorganism, the best solution for this disappoint is to tap the natural resources which are least explored. Calling for a revival of natural product drug discovery will definitely end up with positive results [48], [49], [50]. Looking into known microbial sources for antibiotics will require high time and work and may or may not end up with isolation of a new class of antibiotics. It is estimated that the atleast 10^7 strains must be screened before reaching a new class of antibiotics [39]. The pharmaceutical companies definitely will not be interested in doing such cumbersome process with less probability for success. Hence identifying a better source for searching a new antibiotics class with a minimal investment of energy, tie and money will be preferred.

V. UNTAPPED NATURAL RESOURCES FOR ANTIBIOTIC RESEARCH

Majority of the world biodiversity remains unexplored. Only 250 – 3,00,000 species have been identified, reported and deposited [51], [52]. Many of the microbes are unculturable and the estimate goes to 99% of the total microbial population [50], [53]. They are generally not culturable under laboratory parameter setup [54], [55]. Natural products research is the available route to explore new antibiotics from untapped natural resources. Microbes living in unique surroundings and extreme environments are one of the least explored living forms in this context [56], [57], [58]. Extreme conditions of salinity, pH, and temperature can be digged in to isolate novel organisms with good antimicrobial properties. Searching the sources including marine soil and water and weeds will yield new antibiotics [59], [60]. Halophiles are the potent targets that can be isolated and cultured in laboratory for the extraction of antibiotics. Nearly all bacteria possess the ability to produce antimicrobial substance and so are halophiles. The antibiotics produced by halophiles are called by the name halocin [61].

VI. HALOCIN

Of all the fermentation products produced by halophiles, halocin is gaining importance largely due to the resistance issues of existing antibiotics. Nearly all halophiles have a universal behavior to secrete halocin as a measure for protection and survival in an environment. Halocins extracted and characterized so far belong to different categories as peptide and protein halocins based on their molecular weight. So far 7 halocin were identified and reported. Of them 5 belong to peptide halocin and the rest 2 belong to protein halocin. The molecular weights of these halocins lie within 3 – 35 kDa with varying thermal, pH stability and salt dependence. These are generally expressed in the transition between exponential and stationary phases. Halocin has proven records for its activity against other closely related microbes [62].

REFERENCES

[1] S. Rodriguez Couto, "Exploitation of biological wastes for the production of value-added products uncler solid-state fermentation conditions," *Biotechnology Journal*. 2008.

[2] J. D. Brooks and S. H. Flint, "Biofilms in the food industry: Problems and potential solutions," *Int. J. Food Sci. Technol.*, 2008.

[3] Y. Sun and J. Cheng, "Hydrolysis of lignocellulosic materials for ethanol production: a review.," *Bioresour. Technol.*, 2002.

[4] M. Galbe, P. Sassner, A. Wingren, and G. Zacchi, "Process engineering economics of bioethanol production," *Adv. Biochem. Eng. Biotechnol.*, 2007.

[5] R. R. De La Haba, D. R. Arahal, C. Sánchez-Porro, and A. Ventosa, "The family halomonadaceae," in *The Prokaryotes: Gammaproteobacteria*, 2014.

[6] A. Poli, F. Ilaria, R. Ida, G. Alessia, L. Lama, and B. Nicolaus, "Microbial Diversity in Extreme Marine Habitats and Their Biomolecules," *Microorganisms*, 2017.

[7] A. Oren, "Microbial life at high salt concentrations: Phylogenetic and metabolic diversity," *Saline Systems*, 2008.

[8] J. F. Imhoff and F. Rodriguez-Valera, "Betaine is the main compatible solute of halophilic eubacteria," *J. Bacteriol.*, 1984.

[9] Y. Ma, E. A. Galinski, W. D. Grant, A. Oren, and A. Ventosa, "Halophiles 2010: Life in saline environments," *Applied and Environmental Microbiology*. 2010.

[10] S. DasSarma, "Extreme Halophiles Are Models for Astrobiology," *Microbe Mag.*, 2016.

[11] L. N. Csonka, "Physiological and genetic responses of bacteria to osmotic stress.," *Microbiol. Rev.*, 1989.

[12] S. Podell *et al.*, "Seasonal fluctuations in ionic concentrations drive microbial succession in a hypersaline lake community," *ISME J.*, 2014.

[13] J. Quillaguamán, H. Guzmán, D. Van-Thuoc, and R. Hatti-Kaul, "Synthesis and production of polyhydroxyalkanoates by halophiles: Current potential and future prospects," *Applied Microbiology and Biotechnology*. 2010.

[14] J. Yin, J. C. Chen, Q. Wu, and G. Q. Chen, "Halophiles, coming stars for industrial biotechnology," *Biotechnology Advances*. 2015.

[15] R. Selvarajan, T. Sibanda, M. Tekere, H. Nyoni, and S. Meddows-Taylor, "Diversity analysis and bioresource characterization of halophilic bacteria isolated from a South African saltpan," *Molecules*, 2017.

[16] S. DasSarma, B. R. Berquist, J. A. Coker, P. DasSarma, and J. A. Müller, "Post-genomics of the model haloarchaeon Halobacterium sp. NRC-1," *Saline Systems*, 2006.

[17] M. Vidyasagar, S. Prakash, S. K. Jayalakshmi, and K. Sreeramulu, "Optimization of culture conditions for the production of halothermophilic protease from halophilic bacterium Chromohalobacter sp. TVSP101," *World J. Microbiol. Biotechnol.*, 2007.

[18] M. Zanjirband, R. Kasra-Kermanshahi, and N. Golbang, "Isolation of Moderately Halophilic Indigenous Bacterial strains producing salt-tolerant exteracellular hydrolytic enzymes;The effect of NaCl salt on enzyme production," *Iran. J. Biol.*, 2009.

[19] R. Rohban, M. A. Amoozegar, and A. Ventosa, "Screening and isolation of halophilic bacteria producing extracellular hydrolyses from Howz Soltan Lake, Iran," *J. Ind. Microbiol. Biotechnol.*, 2009.

[20] H. Babavalian, M. A. Amoozegar, A. A. Pourbabaee, M. M. Moghaddam, and F. Shakeri, "Isolation and identification of moderately halophilic bacteria producing hydrolytic enzymes from the largest hypersaline playa in Iran," *Microbiology*, 2013.

[21] N. S. Abd Samad, A. Amid, D. N. Jimat, and N. A. Ab. Shukor, "Isolation and identification of halophilic bacteria producing halotolerant protease," *Sci. Herit. J.*, 2017.

[22] M. Moshfegh, A. R. Shahverdi, G. Zarrini, and M. A. Faramarzi, "Biochemical characterization of an extracellular polyextremophilic α-amylase from the halophilic archaeon Halorubrum xinjiangense," *Extremophiles*, 2013.

[23] L. M. Timpson *et al.*, "A comparison of two novel alcohol dehydrogenase enzymes (ADH1 and ADH2) from the extreme halophile Haloferax volcanii," *Appl. Microbiol. Biotechnol.*, 2013.

[24] S. Selim, N. Hagagy, M. Abdel Aziz, E. S. El-Meleigy, and E. Pessione, "Thermostable alkaline halophilic-protease production by Natronolimnobius innermongolicus WN18," *Nat. Prod. Res.*, 2014.

[25] S. Sam, F. Kucukasik, O. Yenigun, B. Nicolaus, E. T. Oner, and M. A. Yukselen, "Flocculating performances of exopolysaccharides produced by a halophilic bacterial strain cultivated on agro-industrial waste," *Bioresour. Technol.*, 2011.

[26] H. Guzmán, D. Van-Thuoc, J. Martín, R. Hatti-Kaul, and J. Quillaguamán, "A process for the production of ectoine and poly(3-hydroxybutyrate) by Halomonas boliviensis," *Appl. Microbiol. Biotechnol.*, 2009.

[27] J. Quillaguamán, O. Delgado, B. Mattiasson, and R. Hatti-Kaul, "Poly(β-hydroxybutyrate) production by a moderate halophile, Halomonas boliviensis LC1," *Enzyme Microb. Technol.*, 2006.

[28] D. Tan, Y. S. Xue, G. Aibaidula, and G. Q. Chen, "Unsterile and continuous production of polyhydroxybutyrate by Halomonas TD01," *Bioresour. Technol.*, 2011.

[29] P. Esakkiraj, G. Sandoval, S. Sankaralingam, G. Immanuel, and A. Palavesam, "Preliminary optimization of solid-state phytase production by moderately halophilic Pseudomonas AP-MSU 2 isolated from fish intestine," *Ann. Microbiol.*, 2010.

[30] M. De Lourdes Moreno, M. T. García, A. Ventosa, and E. Mellado, "Characterization of Salicola sp. IC10, a lipase- and protease-producing extreme halophile," *FEMS Microbiol. Ecol.*, 2009.

[31] H. R. Karbalaei-Heidari, M. A. Amoozegar, M. Hajighasemi, A. A. Ziaee, and A. Ventosa, "Production, optimization and purification of a novel extracellular protease from the moderately halophilic bacterium Halobacillus karajensis," *J. Ind. Microbiol. Biotechnol.*, 2009.

[32] M. Gupta, S. Aggarwal, N. K. Navani, and B. Choudhury, "Isolation and characterization of a protease-producing novel haloalkaliphilic bacterium Halobiforma sp. strain BNMIITR from Sambhar lake in Rajasthan, India," *Ann. Microbiol.*, 2015.

[33] M. J. Coronado, C. Vargas, J. Hofemeister, A. Ventosa, and J. J. Nieto, "Production and biochemical characterization of an α-amylase from the moderate halophile Halomonas meridiana," *FEMS Microbiol. Lett.*, 2000.

[34] W. Ren *et al.*, "Purification and properties of a SDS-resistant xylanase from halophilic Streptomonospora sp. YIM 90494," *Cellulose*, 2013.

[35] C. Schiraldi, C. Maresca, A. Catapano, E. A. Galinski, and M. De Rosa, "High-yield cultivation of Marinococcus M52 for production and recovery of hydroxyectoine," *Res. Microbiol.*, 2006.

[36] M. Hamidi, M. S. Hejazi, H. Nazemyieh, M. A. Hejazi, and D. Naziri, "Halorubrum sp. TBZ112, an Extremely Halophilic Carotenoid- Producing Archaeon Isolated from Urmia Lake," *Pharm. Sci.*, 2017.

[37] M. B. S. Donio *et al.*, "Halomonas sp. BS4, A biosurfactant producing halophilic bacterium isolated from solar salt works in India and their biomedical

importance," *Springerplus*, 2013.

[38] P. S. Stewart, "Mechanisms of antibiotic resistance in bacterial biofilms," *Int. J. Med. Microbiol.*, 2002.

[39] K. Lewis, "Platforms for antibiotic discovery," *Nature Reviews Drug Discovery*. 2013.

[40] H. C. Neu, "The crisis in antibiotic resistance," *Science (80-.).*, 1992.

[41] G. M. Rossolini, F. Arena, P. Pecile, and S. Pollini, "Update on the antibiotic resistance crisis," *Current Opinion in Pharmacology*. 2014.

[42] G. L. French, "The continuing crisis in antibiotic resistance," *Int. J. Antimicrob. Agents*, 2010.

[43] J. Davies and D. Davies, "Origins and Evolution of Antibiotic Resistance O," *Microbiol. Mol. Biol. Rev.*, 2010.

[44] J. Bérdy, "Thoughts and facts about antibiotics: Where we are now and where we are heading," *Journal of Antibiotics*. 2012.

[45] H. W. Boucher *et al.*, "Bad Bugs, No Drugs: No ESKAPE! An Update from the Infectious Diseases Society of America," *Clin. Infect. Dis.*, 2009.

[46] M. Bassetti, M. Merelli, C. Temperoni, and A. Astilean, "New antibiotics for bad bugs: Where are we?," *Annals of Clinical Microbiology and Antimicrobials*. 2013.

[47] D. J. Payne, M. N. Gwynn, D. J. Holmes, and D. L. Pompliano, "Drugs for bad bugs: Confronting the challenges of antibacterial discovery," *Nature Reviews Drug Discovery*. 2007.

[48] A. L. Demain and S. Sanchez, "Microbial drug discovery: 80 Years of progress," *Journal of Antibiotics*. 2009.

[49] K. Andries *et al.*, "A diarylquinoline drug active on the ATP synthase of Mycobacterium tuberculosis," *Science (80-.).*, 2005.

[50] J. Clardy, M. A. Fischbach, and C. T. Walsh, "New antibiotics from bacterial natural products," *Nature Biotechnology*. 2006.

[51] S. B. Singh and F. Pelaez, "Biodiversity, chemical diversity and drug discovery," *Progress in Drug Research*. 2008.

[52] Y. W. Chin, M. J. Balunas, H. B. Chai, and A. D. Kinghorn, "Drug discovery from natural sources," in *Drug Addiction: From Basic Research to Therapy*, 2008.

[53] A. L. Demain, "Prescription for an ailing pharmaceutical industry," *Nat. Biotechnol.*, 2002.

[54] M. S. Rappé and S. J. Giovannoni, "The Uncultured Microbial Majority," *Annu. Rev. Microbiol.*, 2003.

[55] K. Lewis, S. Epstein, A. D'Onofrio, and L. L. Ling, "Uncultured microorganisms as a source of secondary metabolites," *Journal of Antibiotics*. 2010.

[56] J. F. Imhoff, A. Labes, and J. Wiese, "Bio-mining the microbial treasures of the ocean: New natural products," *Biotechnology Advances*. 2011.

[57] V. L. Challinor and H. B. Bode, "Bioactive natural products from novel microbial sources," *Ann. N. Y. Acad. Sci.*, 2015.

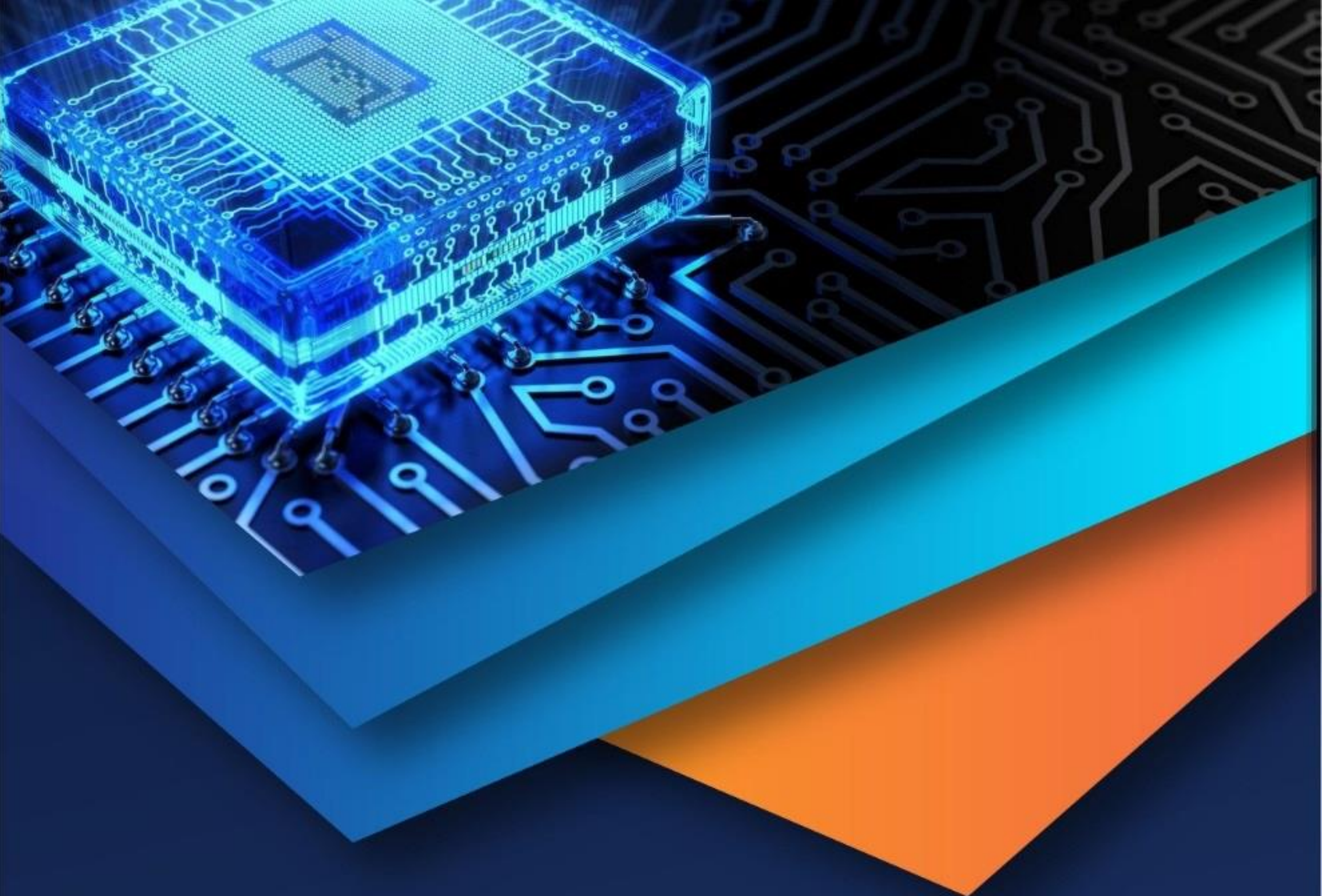
[58] D. Savoia, "Plant-derived antimicrobial compounds: Alternatives to antibiotics," *Future Microbiology*. 2012.

[59] S. Chanda, R. Dave, M. Kaneria, and K. Nagani, "Seaweeds: A novel, untapped source of drugs from sea to combat Infectious diseases," in *Current Research, Technology and Education Topics in Applied Microbiology and Microbila Biotecnology*, 2010.

[60] R. Subramani and W. Aalbersberg, "Marine actinomycetes: An ongoing source of novel bioactive metabolites," *Microbiological Research*. 2012.

[61] M. A. Riley, "MOLECULAR MECHANISMS OF BACTERIOCIN EVOLUTION," *Annu. Rev. Genet.*, 2002.

[62] P. Kavitha, A. P. Lipton,A. R. Sarika and M. S. Aishwarya, "Growth Characteristics and Halocin Production by a New Isolate, Haloferax volcanii KPS1 from Kovalam Solar Saltern (India)," *Research Journal of Biological Sciences*, 2011



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