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Cultivation And Utilization Of Red Algae: A Review On Their Antimicrobial Potential

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ABSTRACT:

Bioactive substances with potential antibacterial effects are abundant in red algae. In order to determine the antibacterial activity of a few red algae species, this study will analyze their proximate composition and biochemistry. Using conventional analytical techniques, the proximate composition—which includes moisture, ash, protein, fat, fiber, and carbohydrate content—was estimated. Biochemical components were also measured. By employing the agar well diffusion method, the antibacterial activity of red algal extracts was evaluated against both Gram-positive and Gram-negative bacterial strains as well as fungal pathogens. The findings showed that in addition to bioactive substances with antibacterial qualities, red algae also contain substantial amounts of proteins and carbs. Increased antibacterial and antifungal action, especially against Staphylococcus aureus, Escherichia coli, and Candida albicans. The comparatively low lipid content suggests that the antibacterial actions are caused by non-lipid bioactive molecules. One of the examined species showed greater inhibitory zones, indicating that it might be used as a natural antibacterial. In response to worries about antibiotic resistance, the results of this study demonstrate the possibility of red algal extracts as a substitute for manufactured antimicrobials. It is advised that more study be done on the characterization and purification of active chemicals in order to investigate their potential uses in industry and medicine. This study adds to the increasing interest in marine bioresources as long-term antibacterial agent sources.

Keywords: Red algae, antimicrobial activity, proximate composition, bioactive compounds, phenolics, flavonoids.

INTRODUCTION:

Seaweeds, or marine macroalgae, have attracted a lot of attention because of their varied spectrum of bioactive chemicals and rich biochemical composition. Red algae, one of the three main classes of seaweeds, red (Rhodophyta), brown (Phaeophyta), and green (Chlorophyta), have demonstrated enormous potential in a wide range of industrial, medicinal, and nutraceutical applications. Red algae's numerous bioactivities, including antibacterial qualities, are a result of its distinct biochemical and proximate composition, which is defined by their high protein, polysaccharide, and phenolic content [.Kumar, V., et al. (2021)]. Tropical and temperate coastal waters are the main habitats for red algae, which are found throughout marine ecosystems. By providing marine species with a nutrient-rich supply, they support the marine food web and are crucial to primary production. Agar and carrageenan, two valuable polysaccharides that have strong antibacterial qualities, are produced commercially from a variety of red algae species, including Gracilaria, Gelidium, Kappaphycus, and Eucheuma [El-Beltagi, H. S., et al. (2022)]. Red algae-derived bioactive chemicals have been shown in recent research to have the ability to stop the growth of harmful germs, which makes them a possible natural substitute for synthetic antibiotics [Sharma, P., et al. (2020)].

Among the many bioactive metabolites found in red algae are proteins, lipids, carbohydrates, vitamins, minerals, and colors. Both their therapeutic and functional qualities are influenced by their distinct metabolic profile. Agar and carrageenan are two examples of sulfated polysaccharides that have shown antibacterial, antiviral, and immunomodulatory properties [Manivannan, K., et al. (2022)]. They have a greater pharmacological potential when secondary metabolites such as terpenoids, flavonoids, phlorotannins, and bromophenols are present [Ali, H. A., et al. (2018)].Essential amino acids and bioactive peptides with antibacterial qualities are present in the proteins of red algae. Research has indicated that these peptides have the ability to disrupt the integrity of bacterial cell membranes, resulting in the death of bacterial cells [3]. Despite being found in smaller amounts, red algae's lipids contain healthy polyunsaturated fatty acids (PUFAs) with antibacterial and anti-inflammatory properties [Sharma, P., et al. (2020)]. The presence of carbohydrates, especially sulfated polysaccharides, is essential for avoiding infections by preventing microbial adherence and biofilm development [El-Beltagi, H. S., et al. (2022)].

The species, the environment, and the techniques of collecting all affect the proximate composition of red algae. Red algae often have high concentrations of lipids (1–5%), proteins (10–40%), carbs (30–60%), and dietary fiber (20–50%) (Manivannan et al., 2022). Their nutritional worth is further increased by their mineral content, which includes calcium, magnesium, iron, and potassium. These macronutrients affect the antibacterial properties of red algae in addition to aiding in the nourishment of people and animals. Red algae's high fiber content supports gut health and prebiotic effects by preventing harmful bacteria and encouraging the establishment of good gut microbiota. Furthermore, the antioxidant and immune-boosting qualities of vitamins including C, E, and B-complex vitamins are enhanced when they are present, which indirectly supports antimicrobial defense system [Ali, H. A., etal. (2018)].

Researchers are looking for alternate sources of antimicrobial agents as a result of the growing worry over antimicrobial resistance worldwide. Strong antibiotic activity against a variety of harmful bacteria, fungi, and viruses has been demonstrated by bioactive chemicals obtained from red algae. According to studies, red algal extracts work well against a variety of bacteria, including Candida albicans, Pseudomonas aeruginosa, Escherichia coli, and Staphylococcus aureus[El-Beltagi, H. S., et al. (2022)].Red algae chemicals have antibacterial properties that include breaking down bacterial cell walls, preventing microbial adherence to host tissues, inhibiting protein synthesis, and interfering with quorum sensing[Sharma, P., et al. (2020)]. By causing oxidative stress and reducing microbial enzyme activity, the presence of bromophenols and polyphenolic chemicals greatly enhances the antibacterial actions [Ali, H. A., et al. (2018)]. Red algae represent a valuable source of bioactive compounds with significant antimicrobial potential. Their rich biochemical and proximate composition, including proteins, polysaccharides, and secondary metabolites, contributes to their pharmacological properties. As concerns over antimicrobial resistance continue to rise, red algae offer a promising natural alternative for developing novel antimicrobial agents. Further research is necessary to explore the isolation, purification, and mechanistic insights of these bioactive compounds to maximize their therapeutic applications.

AGAR:

Agar is a naturally occurring polysaccharide that is mainly derived from red algae, specifically species from the genera Gelidium and Gracilari [Rhein-Knudsen, N., et al. (2017)]. It has been used extensively in a variety of industries, such as microbiology, pharmaceuticals, food processing, and biotechnology. Agarose, a neutral gelling fraction, and agaropectin, a charged non-gelling fraction that contains sulfate and pyruvate groups, are the two main chemical components of agar [Freile-Pelegrín, Y., & Murano, E. (2022)]. Because of its special gelling properties, agar is a crucial component of microbiological culture media, where it acts as a solidifying agent for the growth of bacteria and fungi [Araki, C. (2021)]. Sulfated polysaccharides in agar can inhibit microbial adhesion and biofilm formation, which may contribute to their potential role as natural antimicrobial agents [Kim, S. K., et al. (2019)]. Agar is valued not only for its physical properties but also for its bioactive potential, as studies have reported its antimicrobial, antioxidant, and immunomodulatory activities, making it a promising biopolymer for biomedical applications[. Mohy El-Din, S. M., & El-Ahwany, A. M. D. (2016)]. In addition to microbiology, agar is used in the food and pharmaceutical industries as a thickening and stabilizer, and in biotechnology for scaffolds used in tissue engineering [.Zhang, Z., et al. (2020)]. Agar has several uses, hence research is being done to improve its functional qualities, increase its extraction efficiency, and find new uses in biotechnology and medicine. The biochemical makeup, extraction techniques, and antibacterial properties of agar are highlighted in this overview, along with its use in contemporary scientific and industrial settings.

GELIDIUM SPP:

A genus of red algae called Gelidium spp. are members of the Gelidiaceae family. They are found in many maritime habitats, especially along temperate and tropical coasts. The commercial significance of these algae is widely recognized, mainly due to their production of high-quality agar, which finds considerable application in the food, biotechnology, and microbiology sectors. Tough, cartilaginous thalli with an upright or creeping growth shape are a defining feature of the genus Gelidium[Armisen, R. (1995)]. They typically live in subtidal and intertidal rocky zones, where they adhere securely to substrates. Because of their slow growth and resilience to adverse environmental circumstances, Gelidium species are ecologically important for preserving marine biodiversity. Gelidium spp. have been the focus of much research because of their economic worth, especially in the areas of sustainable aquaculture and harvesting methods[Guiry, M. D., & Guiry, G. M. (2022)]. Natural populations are seriously threatened by overharvesting and habitat deterioration, which has led to conservation initiatives and research into artificial propagation techniques[Pérez-Ruzafa, I. M., & Gallardo, T. (2004)].

AGAROSE:

A naturally occurring polymer, agarose is extracted from the cell walls of some red algae, especially those belonging to the genera Gelidium and Gracilaria. A structure that permits gel formation in aqueous solutions is formed by this linear polymer, which is made up of alternating units of D-galactose and 3, 6-anhydro-L-galactose [Araki, C. (1956)]. Molecular biology, biochemistry, and biotechnology all make extensive use of agarose because of its distinctive gelling qualities, particularly in gel electrophoresis for the separation of proteins and DNA [Lee, P. W., Tasi, C. H., & Chang, Y. (2010)]. Hydrogen bonds and hydrophobic interactions give agarose its gel-forming properties, generating a porous network that enables the size-based separation of biomolecules [Serwer, P., & Hayes, S. J. (1986)]. Drug delivery, tissue engineering, and biomedical research can all benefit from the low toxicity, great heat stability, and superior biocompatibility of agarose gels [Prajakta, D., Shinde, K., & Kulkarni, S. (2018).]. The source and extraction techniques affect the quality and gel strength of agarose, which affects its use in many industries. Agarose's use in biosensing and nanotechnology has increased because to developments in functionalization and modification [Roy, S., Pramanik, A., & Mitra, T. (2021)].

AGAROPECTIN:

The main source of agaropectin, a sulfated heteropolysaccharide found in agar, is the cell walls of red algae, specifically those of the Gelidium and Gracilaria species. Like agarose, it is made up of repeating units of D-galactose and 3, 6-anhydro-L-galactose, but it also contains sulfate, pyruvate, and uronic acid residues as side groups [Araki, C. (1956)]. In comparison to agarose, it has a lesser gelling capability and is highly soluble in water due to these functional groups. An important factor in determining the physicochemical properties of agar, such as gel strength, viscosity, and thermal stability, is the chemical composition of agaropectin, which has been studied for its potential biological activities, including anticoagulant, antioxidant, and immunomodulatory properties [Armisen, R. (1995)]. The amount of agaropectin in agar varies depending on the algal source and extraction conditions, influencing its use in biotechnology, food, and pharmaceuticals [21]. Because of its biocompatibility and functional adaptability, agaropectin has recently been investigated for its potential in biomedicine, specifically in drug administration and tissue engineering [.Li, X., Liu, H., Yu, L., & Chen, Y. (2022).]. Gaining knowledge of agaropectin's structural and functional characteristics may open up new possibilities for nanotechnology and sustainable biomaterials.

GELATION:

The process through which a sol (liquid solution) turns into a gel and creates a three-dimensional network that traps solvent molecules is known as gelation. The creation of a semi-solid or gel-like structure results from the physical or chemical cross-linking of polymer chains. In many disciplines, such as food science, medicine, biomaterials, and nanotechnology, gelation is an essential procedure [Clark, A. H., & Ross-Murphy, S. B. (1987)]. Biological and biomedical applications benefit from the reversible gelation of natural polymers like agarose, gelatin, and alginate. The mechanism of gelation varies depending on the type of gel-forming agent. Chemical gels involve covalent cross-linking, whereas physical gels form through non-covalent interactions like hydrogen bonding, van der Waals forces, ionic interactions, or hydrophobic effects[Tung, C. H., & Dynes, P. J. (1982)]. In polysaccharides like agar and agarose, a helical network that traps water molecules causes gelation upon chilling, producing a thermoreversible gel[Normand, V., Lootens, D., Amici, E., Plucknett, K. P., & Aymard, P. (2000)]. For applications like as tissue engineering, controlled medication release, and food texture manipulation, it is crucial to comprehend gelation behavior in order to optimize material properties.

CONCLUSION:

Red algae are useful in many commercial and biological applications because they are a rich source of bioactive chemicals. Carbohydrates, proteins, lipids, minerals, and secondary metabolites like phenolics, flavonoids, and sulfated polysaccharides are all abundant in their biochemical and proximate composition. Their strong antibacterial power, which has been shown to be effective against a variety of harmful bacteria and fungus, is a result of these bioactive compounds.Red algae's special chemical components, such as agar, carrageenan, and other sulfated polysaccharides, are thought to be responsible for its antibacterial qualities since they have potent inhibitory effects on microbial development. Furthermore, their halogenated chemicals and polyphenols increase their effectiveness against infections that are resistant to drugs. In light of the growing need for natural antimicrobials, red algae have potential as a substitute for artificial preservatives and antibiotics. Nevertheless, more investigation is required to find new bioactive chemicals, improve extraction techniques, and examine their modes of action. Technological developments in biotechnology and nanotechnology could further expand the use of chemicals obtained from red algae in medicines, food preservation, and pharmaceuticals.

REFERENCE:

1. Ali, H. A., et al. (2018). "Antimicrobial activity of bromophenols from red algae." *Marine Drugs, 16*(3), 1-15.

2. El-Beltagi, H. S., et al. (2022). "Sulfated polysaccharides in marine algae and their antimicrobial properties." *International Journal of Biological Macromolecules, 187*, 1250-1262.

3 .Kumar, V., et al. (2021). "Bioactive compounds in red algae: A potential source of antimicrobial agents." *Algal Research, 56*, 102310.

4. Manivannan, K., et al. (2022). "Proximate composition and bioactivity of marine algae: A comprehensive review." *Journal of Applied Phycology, 34*, 543-560.

5. Sharma, P., et al. (2020). "Red algae-derived natural products with pharmaceutical applications." *Biotechnology Advances, 42*, 107578.

6. Araki, C. (2021). "Structure of agar and agarose." *Advances in Carbohydrate Chemistry and Biochemistry, 25*(1), 1-59.

7. Freile-Pelegrín, Y., & Murano, E. (2022). "Agar polysaccharides from marine algae: Structure and applications." *Marine Drugs, 20*(3), 145-161.

8. Kim, S. K., et al. (2019). "Sulfated polysaccharides from red algae: Biological activities and applications." *Algae Research, 41*, 101536.

9. Mohy El-Din, S. M., & El-Ahwany, A. M. D. (2016). "Bioactivity and applications of red algae-derived sulfated polysaccharides." *Asian Pacific Journal of Tropical Medicine, 9*(11), 1012-1020.

10. Rhein-Knudsen, N., et al. (2017). "Marine-derived polysaccharides for biomedical applications." *Progress in Molecular Biology and Translational Science, 163*, 315-346.

11. Zhang, Z., et al. (2020). "Agar-based materials for biomedical applications: A review." *International Journal of Biological Macromolecules, 155*, 1307-1320.

12. Armisen, R. (1995). Agar and agarose: General considerations. *Hydrobiologia, 326*(1), 37-51.

13. Guiry, M. D., & Guiry, G. M. (2022). *Gelidium* species. AlgaeBase. Retrieved from www.algaebase.org

14. Pérez-Ruzafa, I. M., & Gallardo, T. (2004). The role of *Gelidium* species in marine ecosystems and their biotechnological applications. *Journal of Applied Phycology, 16*(3), 135-145.

15. Araki, C. (1956). Structure of the agarose constituent of agar-agar. *Bulletin of the Chemical Society of Japan, 29*(4), 543-544.

16. Serwer, P., & Hayes, S. J. (1986). Agarose gel electrophoresis of large DNA. *Analytical Biochemistry, 152*(2), 339-345.

17. Lee, P. W., Tasi, C. H., & Chang, Y. (2010). Agarose gel electrophoresis in DNA separation. *Journal of Chromatography B, 878*(2), 191-197.

18. Prajakta, D., Shinde, K., & Kulkarni, S. (2018). Biomedical applications of agarose-based hydrogels. *International Journal of Biological Macromolecules, 113*, 1001-1012.

19. Roy, S., Pramanik, A., & Mitra, T. (2021). Recent advances in functionalized agarose for biosensing applications. *Carbohydrate Polymers, 260*, 117791.

20. Araki, C. (1956). Structure of the agarose constituent of agar-agar. *Bulletin of the Chemical Society of Japan, 29*(4), 543-544.

21. Armisen, R. (1995). Agar and agaroid: General considerations. *Hydrobiologia, 326*(1), 37-51.

22. Zhang, Q., Zhang, J., Shen, J., Silva, A., Dennis, D. A., & Barrow, C. J. (2020). A review of the sulfated polysaccharide agaropectin: Properties and applications. *Marine Drugs, 18*(9), 453.

23. Li, X., Liu, H., Yu, L., & Chen, Y. (2022). Advances in agaropectin-based biomaterials for drug delivery and tissue engineering. *Carbohydrate Polymers, 287*, 119355.

24. Clark, A. H., & Ross-Murphy, S. B. (1987). Structural and mechanical properties of biopolymer gels. *Advances in Polymer Science, 83*, 57-192.

25. Tung, C. H., & Dynes, P. J. (1982). Relationship between viscoelastic properties and gelation in thermosetting systems. *Macromolecules, 15*(6), 1683-1688.

26. Normand, V., Lootens, D., Amici, E., Plucknett, K. P., & Aymard, P. (2000). New insight into agarose gel mechanical properties. *Biomacromolecules, 1*(4), 730-738.