E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2021; 9(4): 123-126

www.fisheriesjournal.com
Received: 22-04-2021
Accepted: 08-06-2021

Fittrie Meyllianawaty Pratiwy
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Indonesia

Fajar Nurul Arifah
Student at Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Jl. Raya Sumedang KM 21 Sumedang 45363, Indonesia

Corresponding Author:
Fittrie Meyllianawaty Pratiwy
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Indonesia

The potentiality of endophytes bacterial in red algae as anti-microbial agents in aquaculture: A review

Fittrie Meyllianawaty Pratiwy and Fajar Nurul Arifah

DOI: https://doi.org/10.22271/fish.2021.v9.i4b.2530

Abstract
There are several types of macro algae including brown, green and red algae, which have bioactive compound as anti-microbial agents. Besides that, there are endophytes bacteria that can prevent the growth of disease bacteria, especially bacteria that often attack cultivated species such as *Vibrio* sp. and *Streptococcus* sp. In red Algae, the bioactive compounds produced by endophytes bacteria has many benefits including anti-cancer, anti-coagulant, anti-viral, anti-fungal, anti-bacterial, and anti-inflammatory. Several studies have shown that the use of endophytes bacteria found in red algae can reduce and/or prevent the attack of bacteria on fish and other aquatic organisms. The species from genus *Graciliaria* has as majority found as a source of endophytes and its bioactive compounds. It can against pathogen bacteria could inhibited effectively *Staphylococcus aureus*, *Streptococcus faecalis*, and *Escherichia coli* but not enough power against *Enterobacter aerogenes*. The inhibition zone range 3.1 ± 0.33 mm - 16.33 ± 0.58 mm.

Keywords: Red algae, macroalgae, anti-microbial, pathogens, endophyte

1. Introduction
Macro algae have been as potential source of the anti-microbial sources. The metabolomics analysis from macroalgae indicate the presence of bio-active compounds as antimicrobials [1]. Macro algae are to be the well-known source of bioactive compounds with a wide range of biological activities, such as antibiotics, antioxidant, and anti-inflammatory [2, 3]. Moreover, some macro algae have bioactive components which controlled the propagation of some pathogenic bacteria [4].
The anti-microbial agents from marine alga have been selected through conventional ways as a drug [5]. Several studies have been reported that some primary and secondary metabolites from red marine algae had a potentiality for nutraceutical and the pharmacological industry from its bioactive compounds, based on the competency of inhibiting bacteria[6], viruses, fungal [7] and anticoagulant[8]. The natural bioactive compounds in macro algae with antimicrobial activity, are known as polysaccharides, polyunsaturated fatty acids, tannins and other phenolic compounds, and carotenoids [9]. The bioactive compounds contain macrolides, cyclic peptides, proteins, polyketides, sesquiterpenes, terpenes, and fatty acids[10], which have been reported has potentiality for antibacterial against both Gram-positive and Gram-negative[4]. Mainly problems occurred in aquaculture are caused by disease affected by bacterial, viruses, fungi, or oomycetes. Nowadays, to overcome this case, the farmers mostly used the commercial antibiotics for against that pathogens. Nevertheless, commercial antibiotics have an undesirable side effect, such toxicity to the aquatic organisms and release of chemical residues in the environment. These chemical residues can pose risk to the animal and human health [6]. Thus, it is necessary to use natural antimicrobials against pathogens in aquaculture. Several studies has shown that bacterial endophytes from red alga can against bacterial such as *Gracilaria* sp. [11, 12] *Gracilaria dura* [6], *Centoceras clavulatum* [13], *Laurencia Pacifica* [13] etc. This review will discuss several species from Red algae (*Rhodophyta*) which used for antimicrobial agent to against bacterial disease in aquaculture.

Macro algae for Aquaculture
Macro algae have an important role for a human health, animals and also can additives for diets of aquatic animal [14] such as fish, shrimps etc.

They are known as an essential source of food for benthic organisms [15], antimicrobial [16, 17], antifungal [18], anti-phytopathogenic [19], antioxidant [20], anti-cancer, anti-inflammatory, etc. The use of macro algae as an antimicrobial has been widely used in aquaculture. According to previous research [4] specifically, the antimicrobial compound from red algae extracted uses several types of solvents to extract from red algae including, methanol, diethyl ether, chloroform, ethanol [21].

Against Fungi, Bacterial and Virus

Pathogens such as fungi, bacteria and viruses are the biggest problems in aquaculture activities. This is because the pathogen is able to attack the aquatic commodities so that it can cause death and big losses. Some species belonging to *Aeromonas* and *Vibrio* genera, which are abundantly spread in freshwater and marine waters, have been recognized as pathogenic for a variety of economically important fish and shellfish species, and also for humans, causing enteric pathologies, primary and secondary septicemia, and wound infections [22, 23].

Bioactive Compound in Macro Algae: Red Algae

The concentration of bio-active compound in macro algae could be affected by natural factors such as the environmental conditions, including light, temperature or salinity, the life stage, reproductive state and age of the seaweed, and the geographical location and seasonality. This antimicrobial activity was not credited to a solitary compound; however, it marvelously may be identified together and with a mix of metabolites. Seaweed or macro algae offer an extraordinary assortment of metabolites and natural bioactive compounds with antimicrobial activity, such as polysaccharides, polyunsaturated fatty acids, phlorotannins and other phenolic compounds, and carotenoids [8]. The polysaccharides become the essential components of green, brown and red algae, which may have its capacity and specific functions. In addition, Cell walls of algae are made out of an assortment of polysaccharides including alginic corrosive and alginates, carrageenan and agar, laminaran, fucoidans, ulvans and subordinates [24, 25].

Endophytes Bacterial in Red Algae

Endophytes are microorganisms, which has a role as embryo symbiotic, mostly found as bacteria or fungi that colonize intercellular sites in plants, in natural ecosystems [26, 27]. They are also found in aquatic plants, including algae [11]. Some endophytes produce and discharge bio-active compounds that prevent the pathogenic bacteria, fungi and plant pests from budding in the host plant. These compounds are called secondary metabolites. Similarly, like in plant, currently endophytes bacteria found in macro-algae are widely used as anti-microbial and anti-fungal in aquaculture. The use of endophytes bacteria is able to inhibit the growth of several pathogenic bacteria such as *Vibrio, Streptococcus, Staphylococcus,* and *E.coli.* Several studies has shown that bacterial endophytes from some species in red algae can against bacterial pathogen (Table 1). Based on the previous studies have been shown in Table 1, the genus *Gracillaria* has a majority found as a source of endophytes and its bio-active compounds. Specifically, it can against six bacterial pathogens such as *E. coli, Enterobacter aerogenes, Staphylococcus aureus, P. aeruginosa, Strep. Faecalis and B. cereus.*

Table 1: Isolated endophytes from different red algae, sorted by their ability against some pathogens in aquaculture

Species	Endophytes Bacteria	Pathogens Bacteria	References
Gracollariopsis longissimi	N/A	*V. ordalii, V. salmonicida, V. alginolyticus, V. vulnficus*	
Gracillaria dura	N/A	*V. ordalii* and *V. alginoolyticus*	[6]
Gracilaria aracilis	N/A	*Vibrio salmonicida*	
Gracilaria edulis	N/A	*E. coli, P. aeruginosa, S. aureus,* and *S. faecalis*	[4]
Centroceros clavulatum	*Tenacibaculum*	*P. mirabilis*	
Laurencia pacifia Kylin	*Alteromonas*	Weak against *P. mirabilis*	[13]
Laurencia dendroidea	N/A	*S. aureus*	
Gracillaria sp.	N/A	*S. aureus* and *E. colli*	[12]
Hypnea musciformis	N/A	*S. aureus*	
Gracillaria sp.	*Bacillus subtilis*	*P. damselae, Strep. Iniae dan A. salmonicida*	
	Bacillus pumilus	*P. damselae, Strep. Iniae, A. salmonicida* dan *S. parasitica*	
Jania rubens	*Bacillus sibtilis*	*P. damselae, Strep. Iniae, A. salmonicida* dan *S. parasitica*	[11]
	Bacillus safensis	*P. damselae, Strep. Iniae, A. salmonicida* dan *S. parasitica*	
Laurencia papilosa	*Bacillus safensis*	*P. damselae, Strep. Iniae, A. salmonicida* dan *S. parasitica*	
Acanthopora najadiformis	*Bacillus megaterium*	*P. damselae, Strep. Iniae, A. salmonicida*	
	Bacillus gitudnis	*P. damselae, Strep. Iniae, A. salmonicida*	
Spuridia harvey	*Bacillus velezensis*	*P. damselae, Strep. Iniae, A. salmonicida and S. parasitica*	
	Bacillus subtilis	*A. salmonicida and S. parasitica*	
Ceramium rubrum	N/A	*Pseudomonas aeruginosa, Staphylococcus aureus 1, Staphylococcus aureus 2, Staphylococcus aureus 4, Shigella flexneri, and Esherichia coli*	[21]

Potentiality of endophytes bacteria as anti-microbal

Endophytic bacteria found in red algae have great potential as natural antimicrobials. The use of endophytic bacteria has a significant effect in inhibiting pathogens such as bacteria, viruses and fungal. Based on previous study [11], related to antimicrobial activity in several species of algae including *Sargassum vulgare, Sargassum fusiforme, Padina pavonia,* and *Ceramium rubrum.* The use of several species of algae for antibacterial activity uses several organic solvents such as diethyl ether, ethanol, methanol, chloroform [21], acetone and toluene [28]. The bioactive compounds secrete from endophytes bacteria in red algae reported can inhibit the growth of pathogen bacteria as shown in Table 2. The highest inhibition zone (mm) showed the bioactive compounds produced from *Ceramium rubrum* against *S. aureus,* which typically causes skin infections in fish and shrimp. Besides that, the species from genus *Graciliaria* could inhibited effectively Staphylococcus aureus, *Streptococcus faecalis,* and *Esherichia coli* but not enough power against *Enterobacter aerogenes.*

Table 2: Inhabitation activity from bioactive compounds of red algae as anti-microbial

Algae Species	Pathogens Bacteria	Inhibition Zone (mm)	References
Graciliaria edulis	*Esherichia coli*	11.9 ± 0.2	[4]
	Bacillus cereus	4.2 ± 0.3	
	Enterobacter aerogenes	3.1 ± 0.3	
	Pseudomonas aeruginosa	11.2 ± 0.9	
	Staphylococcus aureus	13.7 ± 0.7	
	Streptococcus faecalis	12.1 ± 0.5	
Laurencia dendroidea	*S. aureus*	250 µg/ml	[12]
Gracillaria sp.	*S. aureus* dan *E. coli*	500 µg/ml dan 1000 µg/ml	
Hypnea musciformis	*S. aureus*	1000 µg/ml	
Ceramium rubrum	*Pseudomonas aeruginosa*	15.67 ± 0.57	[21]
	Staphylococcus aureus 1	16.33 ± 0.58	
	Staphylococcus aureus 2	8.33 ± 0.28	
	Staphylococcus aureus 4	15.67 ± 0.57	
	Esherichia coli	11.67 ± 0.57	
	Shigella flexneri	11.67 ± 0.58	

Conclusion

Based on the endophytic bacteria found in macroalgae, especially red algae, this review shows the potential of macroalgae as an anti-microbial to inhibit the growth of pathogenic bacteria using endophytic bacteria. Several species of red algae are known for their endophytic bacteria including *Bacillus*, *Tenacibaculum*, and *Alteromonas* which are able to inhibit the growth of pathogenic bacteria such as the genera *Vibrio*, *Streptococcus*, *Staphlococcus*, *E.coli*, *Pseudomonas*, *P. mirabilis*, and *Shigella*. The inhibition zone range is 3.1 ± 0.3mm - 16.33 ± 0.58 mm. Thus, red algae have enormous potential in the future as an environmentally friendly anti-microbial, which has few side effects to both fishery commodities and the environment.

References

1. Chiheb I *et al*. Screening of Antibacterial Activity in Marine Green and Brown Macroalgae. Afr. J. Biotech 2009;8:1258-1262.
2. Tuney I. *et al*. Antimicrobial Activities of Extracts of Marine Algae from The Coast of Urla (Izmir, Turkey). Turk J. Biol 2006;30:171-175.
3. Patra J *et al*. Evaluation of Antioxidant and Antimicrobial Activity of Seaweed (*Sargassum* sp.) Extract: A Study on Inhibition of Glutathione-S Transferase Activity. Turk. J. Biol 2008;32:119-125.
4. Kolanjinathan K, Ganesh P, Govindarajan M. Antibacterial Activity of Ethanol Extracts of Seaweeds Against Fish Bacterial Pathogens. Eur. Rev. Med. Pharmacol. Sci 2009;13:173-177.
5. Barbosa F. *et al*. Targeting Antimicrobial Drug Resistance with Marine Natural Product. Int. J Antimicro 2020;5:1-29.
6. Cavallo RA *et al*. Antibacterial Activity of Marine Macroalgae Against Fish Pathogenic Vibrio Species. Cent. Eur. J. Biol 2013;8:646-653.
7. Smit AJ. Medicinal and Pharmaceutical Uses if Seaweed Natural Products: A Review. J Appl. Phycol 2004;16:245-262.
8. Pushpamali WA *et al*. Isolation and Purification of an Anticoagulant from Fermented Red Seaweed Lomentaria catenate 2008;73:274-279.
9. Pérez MJ, Falqué E, Domínguez H. Antimicrobial Action of Compounds from Marine Seaweed. Mar. Drugs 2016;14:1-38.
10. Wijesinghe WAJP, Jin Jeon Y. Biological Activities and Potential Industrial Applications of Fucose Rich Sulphated Polysaccharides and Fucoidans Isolated from Brown Seaweed: A Review. Carbo. Poly 2012;88:13-20.
11. Deutsch Y *et al*. Endophytes from Algae a Potential Source for New Biologically Active Metbaolites for Disease Management in Aquaculture. Front. Mar. Sci 2021;8:1-13.
12. Bianco EM *et al*. Antimicrobial (Including antimollicutes), Antioxidants and Anticholinesterase Activities of Brazilian and Spanish Marine Organisms Evaluation of Extracts and Pure Compound. Rev. Brasil. Farmac 2015, 1-9.
13. Villarreal-Gomez LJ *et al*. Antibacterial and Anticancer Activit of Seaweeds and Bacteria Associated with Their Surface. Rev. Biol. Mar. Ocean 2010;45:267-275.
14. Pratiwy FM, Kohbara J, Susanto AB. Effectiveness of *Sargaasum* meal as Feed Additive on Growth Performance of Nile Tilapia, *Oreochromis niloticus.* Aquac. Sci 2018;66:25-31.
15. Pereira L, Correia FJS. Algas Marinhas da Costa Portuguesa- Ecologia, Biodiversidade e Utilizações 1st Edition. Nota de Rodapé Edições 2018. ISBN: ISBN: 978-989-20-5754-5.
16. Silva A *et al*. Macroalgae as a source of Valuable Antimicrobial Compounds: Extraction and Applications. Antibiotics 2020;9:1-41.
17. Silva A, Silva S *et al*. Antibacterial Use of Macroalgae Compounds Against Foodborne Pathogens. Antibiotics 2020;9:1-41.
18. Cosoveanu A, Axine O, Iacomi B. Antifungal Activity of Macroalgae Extracts. Sci. Papers 2010;52:442-447.
19. Jimenez E *et al*. Anti-Phytopathogenic Activities of Macro Algae Extract. Mar. Drugs 2011;9:739-756.
20. Pratiwy FM, Pratiwi DY. The Effects of Bioactive Compound (Antioxidant) from *Sargassum* Extract on The Erythrocytes and Differential Leucocytes of Catfish (*Clarias* sp.). Int. J. Fish. Aqua. Stud 2020;8(6):123-126.
21. El-Shafay SM, Ali SS, El-Sheekh MM. Antimicrobial Activity of Some Seaweed Species from Red Sea, Against Multidrug Resistant Bacteria. Egypt. J Aqua. Research 2015, 1-10.
22. Thompson JR, Marcelino LA, Polz MF. Diversity, Sources, and Detection of Human Bacterial Pathigens in the Marine Environment - In S Belkin and RR Colwell, Oceans and Health: Pathogens in the Marine Environment. New York 2005, 29-68.
23. Toranzo AE, Magarinos B, Romalde JL. A Review of the Main Bacterial Fish Diseases in Mariculture Systems.

Aquaculture 2005, 37-61.
24. Balboa EM *et al*. *In Vitro* Antioxidant Properties of Crude Extracts and Compounds from Brown Algae. Food Chem 2013;138:1764-1758.
25. Usov AI. Chemical Structures of Algal Polysaccharides. – in Dominguez H, Functional Ingredients from Algae for Foods and Nutraceuticals. Woodhead Publishing. Cambridge, UK 2013, 23-86.
26. Liarzi O, Ezra D. Endophyte-mediated Biocontrol of Herbaceous and Non-Herbaceous Plants. – in C, Verma., Vijay., & C, G, Alan. Advances in Endophytic Research Eds V. New Delhi: Springer 2014, 335-369.
27. Gouda S *et al*. Endophytes: A Treasure House of Bioactive Compounds of Medicinal Importance. Front. Microbiol 2016, 1538.
28. Ponnanikajamideen M *et al*. Bioactivity and Phytochemical Constituents of Marine Brown Seaweed (*Padina tetrastromatica)* extract from Various Organic Solvents. Int. J Pharm. Therap 2014;5:108-112.