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

Fittrie Meyllianawaty Pratiwy and Fajar Nurul Arifah

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Abstract

There are several types of macro algae including brown, green and red algae, which have bioactive compounds 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 Gracilaria 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 alga (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.

Corresponding Author:
Fittrie Meyllianawaty Pratiwy
Department of Fisheries, Faculty of Fisheries and Marine Sciences, Universitas Padjadjaran, Indonesia
They are known as an essential source of food for benthic organisms [15], antimicrobial [16, 17], antifungal [18], antiphytopathogenic [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 alginites, 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 [15]. 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 study, some species in red algae have 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 |
|-----------------------------|---------------------------|--------------------------|------------|
| *Gracillariopsis longissimi*| N/A                       | V. ordalii, *V. salmonicida*, *V. alginolyticus*, *V. vulnificus* | [6]        |
| *Gracilaria dura*           | N/A                       | *V. ordalii* and *V. alginolyticus* | [12]       |
| *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 pacifica Kylin*  | *Alteromonas*             | Weak against *P. mirabilis* | [13]       |
| *Laurencia dendroida*       | N/A                       | *S. aureus*              |            |
| *Gracillaria sp.*           | N/A                       | *S. aureus* and *E. coli* | [12]       |
| *Hypnea musciformis*        | N/A                       | *S. aureus*              |            |
| *Gracillaria sp.*           | *Bacillus subtilis*       | *P. damselae, Strep. Iniae dan A. salmonicida* |            |
| *Jania rubens*              | *Bacillus pumilus*        | *P. damselae, Strep. Iniae, A. salmonicida dan S. parasitica* | [11]       |
| *Bacillus subtilis*         | *Bacillus safensis*       | *P. damselae, Strep. Iniae, A. salmonicida dan S. parasitica* | [11]       |
| *Laurencia papillosa*       | *Bacillus safensis*       | *P. damselae, Strep. Iniae, A. salmonicida dan S. parasitica* |            |
| *Acanthopora najadiformis*  | *Bacillus megaterium*     | *P. damselae, Strep. Iniae, A. salmonicida* | [13]       |
| *Bacillus gitudn*           | *Bacillus gitudn*         | *P. damselae, Strep. Iniae, A. salmonicida* | [11]       |
| *Spuridia harvey*           | *Bacillus velezensis*     | *P. damselae, Strep. Iniae, A. salmonicida and S. parasitica* | [13]       |
| *Ceramium rubrum*           | N/A                       | *A. salmonicida and S. parasitica* |            |

**Potentiality of endophytes bacteria as anti-microbial**
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 fusiiforme*, *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 *Gracillaria* could inhibited effectively *Staphylococcus aureus*, *Strepococcus faecalis*, and *Esherichia coli* but not enough power against *Enterobacter aerogenes*.
Table 2: Inhibition activity from bioactive compounds of red algae as anti-microbial

| Algae Species       | Pathogens Bacteria | Inhibition Zone (mm) | References |
|---------------------|--------------------|----------------------|------------|
| Gracillaria 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 dendroides| 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        |            |
|                     | Staphylococcus aureus 1 | 16.33 ± 0.58      | [21]       |
|                     | 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, Staphylococcus, 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.

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