



International Journal of Fisheries and Aquatic Studies

E-ISSN: 2347-5129

P-ISSN: 2394-0506

(ICV-Poland) Impact Value: 5.62

(GIF) Impact Factor: 0.549

IJFAS 2021; 9(4): 127-130

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www.fisheriesjournal.com

Received: 23-04-2021

Accepted: 09-06-2021

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The bioactive compounds and microbial endophytes from brown seaweed as antibacterial for aquaculture disease management: A review

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DOI: <https://doi.org/10.22271/fish.2021.v9.i4b.2531>

Abstract

Brown seaweed contain bioactive compounds such as flavonoids, steroids, triterpenoids, alkaloids, saponins, tannins that have antimicrobial potential. The use of brown seaweed extract in several studies has reported that brown seaweed extract has a capability to inhibit the activity of bacteria such as *S. aureus* and *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* bacteria, these bacteria are bacteria that attack aquatic organisms such as fish. Endophytic microbes associated with seaweed such as bacteria and fungi are thought to be able to produce the same bioactive compounds as their host, seaweeds. Several studies have also shown that the antibacterial activity of endophytic microbes can inhibit pathogenic bacteria. Most of results showed that the extract of brown seaweed could inhibit the pathogens ranged moderate to strong category.

Keywords: Brown seaweed, bioactive compounds, microbial endophytes, antibacterial

1. Introduction

Seaweed contains primary and secondary metabolites, one of the secondary metabolites found in seaweed is bioactive compounds [1]. The secondary which contain in seaweeds, namely bioactive metabolites has potential roles as antibacterial, antiviral, antifungal, and cytostatic [2]. Seaweeds and its bioactive compounds have an important role as anti-bacterial agents against various type of pathogens. It showed a significant effect as antimicrobial, but the level of efficacy is depends on species and type. The extract of various species of seaweed have been reported have a potential as anti-bacterial, however, *A. sparagopsi* sp. (red seaweed) and *Sargassum* sp. (brown seaweed) are widely known have antibacterial properties against pathogens of fishes and shrimp [3], *Sargassum swartzii* was able to inhibit the pathogens such as *S. aureus*, *A. hydrophila*, *P. aeruginosa*, *V. vulnificus* [4].

Besides bioactive properties, the seaweeds have symbiosis with microorganism that colonize tissues and live between cells in plants and algae, including bacteria, fungi, archaea, and protists, but bacteria and fungi [5]. Bioactive compounds produced by endophytic bacteria can be used as antibacterial [6]. Several studies has shown that endophytic bacteria from brown seaweed were able to inhibit the pathogens such as *Staphylococcus aureus* [7, 8, 9, 10, 11], *Pseudomonas aeruginosa* [10, 11], and *Klebsiella pneumoniae* [11]. In addition, endophytic fungi were isolated from brown seaweed *S. oligocystum*, *S. polycystum*, and *P. minor* also have the potential as antibacterial to against *S. aureus* [12]. Our review will focus on bioactive compounds from extract brown seaweed and its endophytes which are associated with as antibacterial for aquaculture disease management.

Bioactive Compounds from Brown Seaweed

Brown seaweed have potential as immune-stimulants because brown algae contain active compounds such as phenolics, flavonoids, saponins, tannins, steroids, alkaloids and glycosides that have antifungal, antibacterial and antiviral functions [13]. This is in accordance with several research results, which reported that the phytochemical test results of brown seaweed extracts from the genus *Sargassum*, *Padina*, and *Turbinaria* have bioactive compounds such as flavonoids, saponins, tannins, steroids, alkaloids, glycosides and phenolics. In addition, they are able to inhibit pathogenic bacteria *S. aureus*, *A. hydrophila*, *P. aeruginosa*, *V. vulnificus*, *V. alginolyticus*, and *Klebsiella pneumoniae* (Table 1).

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Microbial Endophytes from brown seaweed

Endophytic microbes are microbes in the form of bacteria and fungi that most of their lives are found in the plant body and are not harmful to the host plant [7]. Besides that, there are endophytes come from fungi that can produce secondary metabolites and bioactive compounds similar to the plants that host them [14]. Bioactive compounds obtained from endophytic microorganisms have important roles in the health sector, namely as antifungals, antibiotics, antioxidants, anticancer, antivirals, as well as immunosuppressive ingredients. Therefore, endophytic microorganisms can be used as a substitute for the plant that is the host [15]. Several

endophytic bacteria and fungi were found in brown algae, namely the endophytic bacteria *L. plantarum* associated with brown seaweed *T. conoides* with *Bacillus*, sp [8]; *Yersinia* sp. and *T. ornata* with *Bacillus* sp. [9]; *S. sabrepandum* with *Bacillus cereus* [10]; *Bacillus thuringiensis* from *Padina* sp. [7]; endophyte actinomycetes *Nocardiosis* sp. from *S. wightii* and *T. ornate* [11]. Endophyte fungal *A. terreus* and *Cunninghamella elegans* in brown seaweed *S. oligocystum*, endophyte fungal *Trichoderma viride*, *A. niger*, *P. notatum*, *P. rubens* in brown seaweed *S. polycystum*, and *Pencillium citrinum* in brown seaweed *P. minor* [12].

Table 1: Antibacterial activity of bioactive compounds and endophytic microbes from various brown seaweeds

Seaweed Species	Form	Bioactive Compound	Endophytes		Pathogen Bacteria	Inhibition Zone	References
			Bacteria	Fungal			
<i>Sargassum swartzii</i>	Ethanol extract, methanol extract, acetone extract	Steroids, Tanins, Terpenoids, Flavonides, Saponins, Reducing sugar, Coumarins, Phlobatannin, Anthraquinones, Glycosides, Phenols	NA	NA	<i>S. aureus</i> , <i>A. hydrophila</i> , <i>P. aeruginosa</i> , <i>V. vulnificus</i>	11.33±0.57 mm (ethanol 100µg/mL), 8.66±0.57 mm (50µg/mL), 8.66±0.57 mm (methanol 50µg/mL), 14.66±0.57 mm (ethanol 50µg/mL)	4
<i>Padina australis</i>	extract	Flavonoid, Steroid	NA	NA	<i>S. aureus</i>	8,06 ± 1,12 (cons. 5%/250 µL)	16
<i>Sargassum binderi</i>		Flavonoid, Saponin, Steroid	NA	NA	<i>S. aureus</i>	6,89 ± 0,56 7,04 mm (cons. 5%/250 µL)	
<i>Sargassum oligocystum</i>	N-hexana extract	Phenolic, Flavonoid, Steroid, Triterpenoids	NA	NA	<i>V. alginolyticus</i>	12 mm (cons. 100%)	2
<i>Turbinaria Ornate</i>	Aquades extract	NA	NA	NA	<i>V. alginolyticus</i>	6 mm (cons. 75%)	
<i>Padina australis</i>	Aquades extract	NA	NA	NA	<i>V. alginolyticus</i>	6.5 mm (cons. 75%)	
<i>Turbinaria conoides</i>	Bacteria	NA	<i>L. plantarum</i>	NA	<i>S. aureus</i>	6.7 mm (40 µL)	8
<i>Sargassum polycystum</i>	Etanol extract	Alkaloid, Flavonoid, Saponin, Steroid, Terpenoid	NA	NA	<i>S. aureus</i>	5.97±5.09 mm (40 µL; cons. 40%)	17
<i>Sargassum oligocystum</i>	Fungi	NA	NA	<i>A. terreus</i> , <i>Cunninghamella elegans</i>	<i>S. aureus</i>	9.5 mm±0.09, 25.83±0.97 mm	12
<i>Sargassum polycystum</i>	Fungi	NA	NA	<i>Trichoderma viride</i> , <i>A. niger</i> , <i>P. notatum</i> , <i>P. rubens</i>	<i>S. aureus</i>	48.58±1.30 mm, 6 mm, 13±0.13 mm, 17.76±0.32 mm	
<i>Padina minor</i>	Fungi	NA	NA	<i>Pencillium citrinum</i>	<i>S. aureus</i>	20.17±1.02 mm	
<i>Sargassum wightii</i>	ethyl-asetat extract	Flavonoids, Terpenoids, glycoides	NA	NA	<i>S. aureus</i> , <i>P. aeruginosa</i> , <i>Klebsiella pneumoniae</i>	7 mm (100 µg/mL), 7 mm (150µg/mL), 7 mm (50µg/mL)	18
<i>Turbinaria ornata</i>	Bacteria	NA	<i>bacillus</i> sp., <i>Yersinia</i> sp.	NA	<i>S. aureus</i>	7.33 mm, 6.67 mm	9
<i>Sargassum sabrepandum</i>	Bacteria	NA	<i>Bacillus</i> sp. JS	NA	<i>S. aureus</i> , <i>P. aeruginosa</i>	6 mm (50µg/disc) with media 50% sea water, contained (g/l) : yeast extract 3, glucose 10, meat extract 1.5 and peptone 6. 8 mm (50µg/disc)	10
<i>Padina</i> sp.	bacteria	NA	<i>Bacillus cereus/Bacillus thuringiensis</i>	NA	<i>S. Aureus</i>	7.66 mm (50µg/mL)	7
<i>Sargassum wightii</i> , <i>Turbinaria ornata</i>	Bacteria and ethyl acetate extract	NA	<i>Nocardiosis</i> sp.	NA	<i>S.aureus</i> , <i>P. aeruginosa</i> , <i>Klebsiella pneumoniae</i>	15 mm, 15 mm, 14 mm (100µg/mL ethyl acetate)	11

NA: Not Available

Antibacterial activity of bioactive compounds and microbial endophytes from brown seaweed

The antibacterial activity of brown seaweed extract, which contains various active compounds, shows the ability to inhibit pathogenic bacteria (Table 1). *Sargassum swartzii* was able to inhibit *S. aureus*, *A. hydrophila*, *P. aeruginosa*, and *V. vulnificus* with inhibition zones of 11.33 ± 0.57 mm, 8.66 ± 0.57 mm, 8.66 ± 0.57 mm, 14.66 ± 0.57 mm, respectively [4]. In addition, *P. australis*, *S. binderi*, and *S. polycystum* inhibited *S. aureus* with inhibition zones of 8.06 ± 1.12 mm, 6.89 ± 0.56 mm, 7.04 mm, 5.97 ± 5.09 mm [16, 17]. *S. oligocystum*, *T. ornata*, and *P. australis* inhibited *V. alginolyticus* [2]. *Sargassum wightii* inhibited the bacteria *S. aureus*, *P. aeruginosa*, *Klebsiella pneumoniae* with inhibition zones of 7 mm (100 g/mL), 7 mm (150 µg/mL), 7 mm (50 µg/mL) [18] (Table 1). The antibacterial activity of brown seaweed extracts have the inhibition zone ranged from 5.97 ± 5.09 mm- 14.66 ± 0.57 mm. Furthermore, endophytic microbes obtained from several species of brown seaweed also have the potential as antibacterial to fight pathogens such as *Bacillus sp.*, *Yersinia sp.*, *L. plantarum* and *Bacillus cereus/Bacillus thuringiensis* bacteria that can inhibit *S. aureus* with inhibition zone ability 7.33 mm, 6.67 mm, 6.7 mm, 7.66 mm [9, 8, 7]. *Bacillus sp.* could inhibited *S. aureus* and *P. Aeruginosa* [10]. Meanwhile, *Nocardiopsis sp.* could inhibited *S. aureus*, *P. aeruginosa*, *Klebsiella pneumonia* with inhibition zones of 15 mm, 15 mm, 14 mm [11]. Endophytic fungus *A. terreus*, *Cunninghamella elegans*, *Trichoderma viride*, *A. niger*, *P. notatum*, *P. rubens*, and *Pencillium citrinum* have ability to inhibit *S. aureus* [12] (Table 1). Based on these reports, it showed that bioactive compounds and endophytic microbes isolated from brown seaweed have the ability to inhibit pathogenic bacteria with the ability to inhibit talent in the moderate to very strong category. Based on the area of inhibition zone that the diameter of the inhibition zone is divided into three categories, specifically weak with a diameter of <5mm, moderate with an inhibition zone of 5-10mm, strong with an inhibition zone of 10-20mm and very strong with an inhibition zone > 20mm [19].

Potentiality of brown seaweed for antibacterial agents in aquaculture

Brown seaweed has been reported to be a good source of antioxidant, the ethanol extract showed the highest antioxidant activity, with an IC₅₀ of 29.84 ppm [20]. Besides its common utility as a feed additive such as *Sargassum* [21], several studies have been reported that the extract of brown seaweed which rich of bioactive compounds have potentiality to prevent the pathogens diseases caused by bacteria and fungal. They could inhibit with inhabitation zone ranged moderate to strong. These benefits can be used in a variety of aquaculture management applications from feeding to use in fish health management.

Conclusion

Based on the bioactive compounds contained, it shows that flavonoids and steroids are the most common compounds found in brown seaweed, followed by terpenoids and saponins. Brown seaweed extract was shown to be able to inhibit pathogenic bacteria with a moderate-strong categories based on the area of inhibition zone. In addition, endophytic microbes obtained from brown seaweed also showed the ability to inhibit pathogenic bacteria that usually attack aquatic animals with moderate to very strong inhibition zones.

So that the use of brown algae, especially endophytic microbes obtained from brown seaweed, has potential as an antibacterial in aquaculture activities. However, it is necessary to conduct *in vivo* research to see the antibacterial activity produced by brown algal endophytic microbes against pathogens bacteria in cultured fish or shrimp.

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