

# Antibacterial Activity of Microalgae *Dunaliella salina*, *Tetraselmis chuii* and *Isochrysis galbana* Against Aquatic Pathogens

*by Ita Widowati*

---

**Submission date:** 10-Aug-2022 08:15AM (UTC+0700)

**Submission ID:** 1880815408

**File name:** C-25-IW-IJMS-2021.pdf (219.11K)

**Word count:** 3685

**Character count:** 19607

## Antibacterial Activity of Microalgae *Dunaliella salina*, *Tetraselmis chuii* and *Isochrysis galbana* Against Aquatic Pathogens

Ita Widowati<sup>1\*</sup>, Muhammad Zainuri<sup>2</sup>, Hermin Pancasakti Kusumaningrum<sup>3</sup>, Yann Hardivillier<sup>4</sup>

<sup>1</sup>Department of Marine Sciences, Faculty of Fisheries and Marine Sciences, Diponegoro University

<sup>2</sup>Department of Oceanography, Faculty of Fisheries and Marine Science, Diponegoro University

<sup>3</sup>Department of Biology, Faculty of Sciences and Mathematics, Diponegoro University

Jl. Prof Soedarto, SH, Tembalang, Semarang -50275, Indonesia

<sup>4</sup>Laboratoire du MMS, Le Mans Université

Av. Olivier Messiaen, 72085 Le Mans, France

Email: itawidowati@lecturer.undip.ac.id

### Abstract

Recently, expanded consideration has been paid to the business and potentiality of microalgae. Some microalgae are at present being studied for their capacity to find important metabolites for the drug industry or aquaculture applications. Concerning these biotechnological challenges, there is a consistent exertion accommodated in both finding and taking advantage of new microalgal assets and fostering their putative business results or modern valorizations. The crude methanol extracts of three microalgae, *Dunaliella salina*, *Tetraselmis chuii*, and *Isochrysis galbana*, have been investigated for antibacterial activity using the disk diffusion method against aquatic pathogens of fish, shrimp, and shellfish e.g. *Pseudomonas fluorescens* and *Vibrio harveyi*. This research aimed to analyze the antibacterial activity of crude extract of these microalgae against aquatic pathogens. The disk diffusion method was used to investigate the antibacterial activity. The result showed that only *T. chuii* has the inhibition zone for both tested bacteria *P. fluorescens* and *V. harveyi* with the inhibition zone of  $3.0 \pm 0.6$  mm on  $100 \mu\text{g} \cdot \text{g}^{-1}$  of extract concentration and  $4.20 \pm 1.1$  mm against *P. fluorescens* on  $10000 \mu\text{g} \cdot \text{g}^{-1}$  of extract concentration. While *D. salina* and *I. galbana* have inhibition zone only for *V. harveyi* with the inhibition zone of  $4.4 \pm 0.6$  mm and  $3.2 \pm 0.7$  mm on  $10000 \mu\text{g} \cdot \text{g}^{-1}$  of extract concentration. These three microalgae may have potential use in aquatic pathogens as antimicrobial agents. It would be possible to develop biologically active compounds of microalgae as a functional feed for aquaculture.

**Keywords:** antibacterial activity, aquatic pathogens, marine microalgae, microalgal extract.

### Introduction

The problems of microbial resistance in aquaculture have led to a search for new antimicrobial compounds. The significant issues of current antimicrobial agents are harmfulness, absence of adequacy, restraining cost, and their frequent use leading to the emergence of resistant strains. Subsequently, there is an earnest need to look for elective biodegradable agents, which should be free from side effects. It is generally that natural compounds are biodegradable and eco-friendly. Microalgae are mainly utilized in aquaculture particularly due to their nutrition contents (Khatoon et al., 2014; Hoai Thu et al., 2015). Besides nutrition advantages, microalgae also have been explored for the use of pigments and other biological purposes. Different species of microalgae are known as a fundamental food source in the rearing of all stages of marine bivalve mollusks (clams, oysters, and scallops), and of the post-larval stages of some marine gastropods (e.g. abalone), larvae of marine fish, penaeid shrimp, and zooplankton. There are

three distinct types of live feed, usually utilized in commercial larvae culture of fish and shellfish: 1). Different species of microalgae ranging between 2  $\mu\text{m}$  and 20  $\mu\text{m}$  in size for bivalves, penaeid shrimps, rotifers, copepods, and fish; 2). The rotifers *Brachionus plicatilis* and *B. rotundiformis* (50 to 200  $\mu\text{m}$ ) in size for crustaceans and marine fish; 3) The brine shrimp *Artemia* sp. nauplii (400 to 800  $\mu\text{m}$ ) in size for crustaceans and fish (Lavens and Sorgeloos, 1996).

The bioactive compound also can be found in macroalgae such as *Sargassum* sp. (antibacterial, antiviral, antioxidants) (Hardouin et al., 2013; Widowati et al., 2014; Susilowati et al., 2015). However, the application of macroalgae for aquaculture is being limited, for example, it cannot be used as feed for larval stages. Microalgae have rich sources of structurally and biologically active metabolites including antioxidants (Widowati et al., 2017) and antibiotics which inhibit bacteria responsible for fish, shellfish, and human pathogens (Pradhan et al., 2011; Najdenski et al., 2013).

\*) Corresponding author  
© Ilmu Kelautan, UNDIP

7 Secondary or primary metabolites produced by these microorganisms may be potential bioactive compounds of interest in aquafeed as an antimicrobial agent (Pradhan *et al.*, 2011). Therefore, some microalgae have been suggested as a new functional feed ingredient (Becker, 2004). This research aimed to determine the antibacterial activity of three species microalgae *Dunaliella salina* (Teodoresco, 1905), *Tetraselmis chuii* (Butcher, 1959), and *Isochrysis galbana* against aquatic pathogens *Pseudomonas fluorescens* (Flügge, 1886) and *Vibrio harveyi* (Johnson and Shunk, 1936; Baumann *et al.*, 1981).

## Materials and Methods

### Culture of microalgae

Three species of microalgae *Dunaliella salina*, *Tetraselmis chuii*, and *Isochrysis galbana* were cultured by using batch continuous culture with the comparison between algae and seawater was 1 : 3 L. Walne was used for the nutritional compound for the culture compared by volume of culture 1 mL: 1 L with luminous intensity 1500 lux to 3000 lux and 23 to 25 °C for temperature (Harrison and Berges, 2005).

The density of the culture microalgae was counted with a Neubauer hemocytometer by using a binocular microscope. The density of the microalgae was counted every day. The microalgae were homogenized first before putting the pipet into the hemocytometer and closed with the cover glass. Then, it was observed under a microscope and started to count with the equation (Hadioetomo, 1993):

$$N = \frac{(N1 + N2)}{2} \times \frac{1}{10.2 \text{ mm}^2 \times 0.1 \text{ mm}} \times \frac{1 \text{ mm}^3}{10^{-3} \text{ mL}}$$

Note: N = Cell density (cell. mL<sup>-1</sup>); N1 = Total cell in 80 small squares (replica 1); N2 = Total cell in 80 small squares (replica 2); 0.2 mm = Wide of hemocytometer in 80 squares; 0.1 mm = The depth liquid on a hemocytometer.

21 The microalgae were harvested on the stationary phase of culture. The biomass of microalgae was obtained with a centrifuge at 5000 rpm (1 rpm equal 1/60 Hz) for 10 min and then dried in a room at view days, then called dry biomass (Mishra *et al.*, 2012).

### Extraction

Extraction involves the separation of plant or animal tissues from inactive or inert components by

using selective solvents in standard extraction procedures. Dry biomass was extracted by using methanol solvent with sonification at 50 Hz for 15 min. Then, the solvents were evaporated by using rotary evaporation until there is no solvent called with crude extract bioactive of microalgae (Trianto *et al.*, 2011).

### Antibacterial activities

The screening of antibacterial activities from extract microalgae against two aquatic pathogens bacteria *Vibrio harveyi* and *Pseudomonas fluorescens* was performed by using the disk diffusion method. The extract of each microalga was diluted into three concentrations *Dunaliella salina* 13.32 µg. g<sup>-1</sup>, 1.33 µg. g<sup>-1</sup>, and 0.13 µg. g<sup>-1</sup>; *Tetraselmis chuii* 12.61 µg. g<sup>-1</sup>, 1.26 µg. g<sup>-1</sup>, and 0.13 µg. g<sup>-1</sup>; *Isochrysis galbana* 13.26 µg. g<sup>-1</sup>, 1.33 µg. g<sup>-1</sup>, and 0.13 µg. g<sup>-1</sup>. One of the 50 µL culture of tested bacteria in the logarithmic phase were spread on to agar medium. Several paper disks (8 mm; Advantec Toyo Roshi, Ltd, Japan) containing 30 µL of each concentration were placed on the respective agar surface. The plates were incubated at room temperature for 48 h. Antibacterial activity was defined by inhibition zones around the paper disk (Radjasa *et al.*, 2009).

## Results and Discussion

### Culture of microalgae

Microalgae were counted for the density every day with a hemocytometer under the microscope binocular. The highest densities are found in *Dunaliella salina* (4.4 x 10<sup>6</sup> cells.mL<sup>-1</sup>), followed by *Isochrysis galbana* (3.2 x10<sup>6</sup> cells.mL<sup>-1</sup>), and the lowest is in *Tetraselmis chuii* (0.96 x 10<sup>6</sup> cells.mL<sup>-1</sup>). However, the highest dry biomass is found in *I. galbana* (3.54 g) and the lowest is in *D. salina* (1.026 g). The highest density in *D. salina* is not in line with the dry biomass, this may be due to the cell size since *D. salina* cell is (2.8-40 µm, Borovkov *et al.*, 2019) and *I. galbana* cell size is 4-6 µm (Cordoba-Matson, 2013). The cell size could change with growth, light intensity, and different condition (Borowitzka, 2021). The result of the density of microalgae *Dunaliella salina*, *Tetraselmis chuii*, and *I. galbana* is shown in Figure 1.

### Extraction

The microalgae were harvested on the stationary phase of culture. Biomass and crude extract of microalgae are shown in Table 1 and 2. The potential of extract microalgae to produce substances

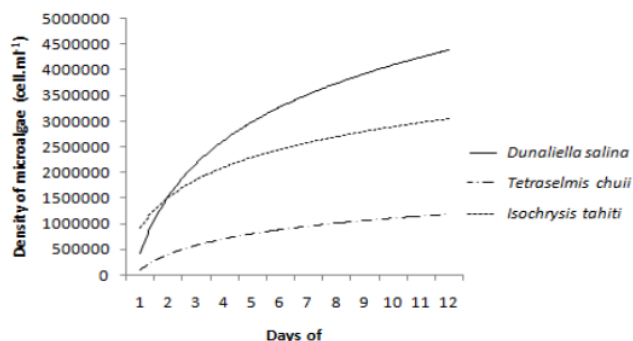


Figure 1. Density of *Dunaliella salina*, *Tetraselmis chuii*, and *Isochrysis galbana* (cell. mL<sup>-1</sup>) x 10<sup>4</sup>.

Table 1. The biomass of microalgae

Species	Wet biomass (g)	Dry biomass (g)
<i>D. salina</i>	6.65	1.026
<i>T. chuii</i>	7.97	1.23
<i>I. galbana</i>	22.65	3.54

Table 2. The result of crude extract of microalgae with methanol solvent

Species	Dry biomass (g)	Extract biomass (g)
<i>D. salina</i>	1.026	0.33
<i>T. chuii</i>	1.230	0.43
<i>I. galbana</i>	3.540	1.69

inhibiting the growth of selected bacteria was evaluated in this research to support the efforts for fulfilling the important need for aquaculture purposes. Antibacterial activities of three species of microalgae *Dunaliella salina*, *Tetraselmis chuii*, and *Isochrysis galbana* against two species of bacteria's aquatic pathogens *Vibrio harveyi* and *Pseudomonas fluorescense* was carried out using the disk diffusion method. The range of the concentrations, *Dunaliella salina* were 13.32 µg.g<sup>-1</sup>, 1.33 µg.g<sup>-1</sup>, and 0.13 µg.g<sup>-1</sup>; *Tetraselmis chuii* were 12.61 µg.g<sup>-1</sup>, 1.26 µg.g<sup>-1</sup>, and 0.13 µg.g<sup>-1</sup>; and *Isochrysis galbana* were 13.26 µg.g<sup>-1</sup>, 1.33 µg.g<sup>-1</sup>, and 0.13 µg.g<sup>-1</sup>, respectively was conducted for the crude extract from methanol solvent of microalgae. Based on the result, the best concentration will be used for the next purification extracted with another solvent.

Furthermore, the organic polar solvent provided extraction yield, ranging from 0.33 g for *Dunaliella salina*, 0.43 g for *Tetraselmis chuii*, and 1.69 g for *Isochrysis galbana*. It was obtained from 3 L and 1.5 L of culture. The crude extract for methanol solvent with high polarity was able to extract the antimicrobial compound. Several authors (Borowitzka, 1995, Ozdemir et al., 2004) have

attributed the cyanobacteria antimicrobial activity to different compounds.

### Antibacterial activities

The antibacterial activities were carried out by using disk diffusion methods. The tested bacteria were counted for their density by using the McFarland standards method (Table 3.). The result of antibacterial activity by using the disk diffusion method against *Vibrio harveyi* is shown in Table 4 and against *Pseudomonas fluorescense* is shown in Table 5. Antibacterial activity of various extracts of the microalgae *Spirulina platensis* (Pradhan et al., 2011), *Euglena viridis* (Das et al., 2005), cyanobacteria (Najdenski et al., 2013), have been reported as the main groups of microalgae to produce antimicrobial substances.

The result of antibacterial activities in this study showed that only *Tetraselmis chuii* provided the inhibition zone against two tested bacteria *V. harveyi* with the inhibition zone 3.0±0.6 mm on 100 µg.g<sup>-1</sup> of extract concentration and 4.2±1.1 mm against *P. fluorescense* on 10 000 µg.g<sup>-1</sup> of extract concentration. The result is similar to the finding that methanol extracts of *Tetraselmis* sp. showed maximum zone of inhibition against *Pseudomonas* sp (Rajendran et al., 2014). Furthermore, Kokou et al (2012) found that *Tetraselmis chuii* and *Isochrysis* sp showed antibacterial activity against six (6) *Vibrio* bacterial strains: *V. parahaemolyticus*, *V. anguillarum*,

Table 3. Results of McFarland standard for bacteria

Bacteria	OD	Cell density (cell. mL <sup>-1</sup> )
<i>Vibrio harveyi</i>	0.671	12 x 10 <sup>8</sup>
<i>Pseudomonas fluorescense</i>	0.107	1.5 x 10 <sup>8</sup>

Note : OD: Optical Density

**Table 4.** Antibacterial activity of microalgae against *Vibrio harveyi*

Species	Inhibition zone (mm)					
	24 h			48 h		
	a <sup>*)</sup>	b <sup>*)</sup>	c <sup>*)</sup>	a <sup>*)</sup>	b <sup>*)</sup>	c <sup>*)</sup>
<i>Dunaliella salina</i>	4.4±0.6	1.8±0.4	0	4.3±0.9	1.8±0.3	0
<i>Tetraselmis chuii</i>	3.5±0.7	2.3±0.3	3.0±0.6	3.5±0.7	2.2±0.3	2.9±0.5
<i>Isochrysis galbana</i>	3.2±0.7	2.9±0.2	2.5±0.8	3.0±0.6	2.9±0.2	2.5±0.7

Note: The concentration of *V. harveyi* for a: 10 000 µg. g<sup>-1</sup>; b: 1000 µg. g<sup>-1</sup>; c: 100 µg. g<sup>-1</sup>; \*) Mean ± SD

**Table 5.** Antibacterial activity of microalgae against *Pseudomonas fluorescence*.

Species	Inhibition zone (mm)					
	24 h			48 h		
	a <sup>*)</sup>	b <sup>*)</sup>	c <sup>*)</sup>	a <sup>*)</sup>	b <sup>*)</sup>	c <sup>*)</sup>
<i>Dunaliella salina</i>	0.0	0.0	0.0	0.0	0.0	0.0
<i>Tetraselmis chuii</i> <sup>*)</sup>	4.2 ± 1.1	3.2 ± 0.5	3.1 ± 0.1	4.2 ± 0.9	2.9 ± 0.2	3.1 ± 0.2
<i>Isochrysis galbana</i>	0.0	0.0	0.0	0.0	0.0	0.0

Note: The concentration of *P. fluorescence* for a: 10 000 µg. g<sup>-1</sup>; b: 1000 µg. g<sup>-1</sup>; c: 100 µg. g<sup>-1</sup>; \*) Mean ± SD

14 *V. splendidus*, *V. scophthalmi*, *V. alginolyticus*, and *V. lentus*. Besides antibacterial activity, *Tetraselmis chuii* is an important producer of fatty acid, and this is an insignificant relationship with environmental conditions (Mohammadi et al., 2015).

Meanwhile, two microalgae, *Dunaliella salina* and *Isochrysis galbana* tested, have the inhibition zone only against *V. harveyi* with the inhibition zone 4.4±0.6 mm and 3.2±0.7 mm on 10000 µg. g<sup>-1</sup> of extract concentration. This result is in agreement with the finding of Molina-Cardenas et al (2014) that demonstrate *Isochrysis galbana* synthesizes antibacterial fatty acids that inhibit the growth of pathogenic bacteria such as *V. harveyi*, *V. alginolyticus*, and *V. campbellii*.

The antimicrobial compounds of microalgae are expected due to their lipids contains. Lipids and some free fatty acids are known to show antibacterial activities from algae (Desbois and Smith, 2010; Plaza et al., 2010). It has been shown that the promoting effect on membrane damage leads to a leakage of molecules from the microbial cells, reduction in nutrient uptake, or inhibition of cellular respiration (Smith et al., 2010). An antibiotically active fatty acid is presented in a high concentration in algae as stated by Hoai Thu et al. (2015), found that *I. galbana* Parke, strain HP has the highest content of Docosahexaenoic acid (DHA), up to 14.7% of total fatty acid and maximal Polyunsaturated fatty acids (PUFAs) values at the early stationary phase. The primary PUFAs are stearidonic acid (18:4n-3) (Nalder et al., 2015).

**Conclusion**

The crude extract of three species microalgae, *Dunaliella salina*, *Tetraselmis chuii*, and

*Isochrysis galbana*, can be used as antibacterial activity against aquatic pathogens *Vibrio harveyi* and *Pseudomonas fluorescence*. The best result for the aquatic purpose was *T. chuii* which can inhibit both pathogenic bacteria *V. harveyi* and *P. fluorescence* and also have antibacterial activities for three replicas. Hence, it is necessary to carry out further research about the availability of microalgae resources as a new functional feed for aquaculture.

11 **Acknowledgments**

The authors would like to thank the Indonesian Ministry of Research, Technology and Higher Education, for funding this research by the Implementation Agreement Assignment Research Collaboration and International Publication No.343-36/UN7.5.1/PP/2017, and also thank Ragil Susilowati and Robertus Triaji Mahendrajaya for helping the culture of microalgae in the laboratory.

**References**

Borovkov, A.B., Gudvilovich, I.N., Memetshaeva, O.A., Avsiyan, A.L., Lelekov, A.S. & Novikova, T.M. 2019. Morphological and Morphometrical Features in *Dunaliella salina* (Chlamydomonadales, Dunaliellaceae) During the Two-phase Cultivation Mode. *Ecol. Montenegrina* 22: 157-165. doi: 10.37828/em. 2019.22.12

Borowitzka, M.A. 2021. The Mass Culture of *Dunaliella salina*. <https://www.fao.org/3/ab728e/ab728e06.html>. Online access: October 26, 2021.

Borowitzka, M.A. 1995. Microalgae as source of pharmaceuticals and biologically active compounds. *J. Appl. Phycol.* 7: 3-15. doi: 10.1007/BF00003544.

- Cordoba-Matson, M.V., Arredondo-Vega, B.O. & Carreón-Palau, L. 2013. Evaluation of growth, cell size and biomass of *Isochrysis* aff. *galbana* (T-ISO) with two LED regimes. *All Res. J. Biol.* 4: 7-15.
- Das, B.K., Pradhan, J., Pattnaik, K., Samantray, B.R. & Samal, S.K. 2005. Production of antibacterials from the freshwater alga *Euglena viridis* (Ehren). *World. J. Microbiol. Biotechnol.* 21: 45-50. doi: 10.1007/s11274-004-1555-3.
- Desbois, A. P & Smith, V.J. 2010. Antibacterial free fatty acids: activities, mechanisms of action and biotechnological potential. *Appl. Microbiol. Biotechnol.* 85: 1629-1642. doi: 10.1007/s00253-009-2355-3.
- Hadioetomo, R.S. 1993. Mikrobiologi Dasar dalam Praktek: Teknik dan Prosedur Dasar Laboratorium. PT Gramedia Pustaka Utama. Jakarta. 163 hal.
- Hardouin, K., Burlot, A.S., Umami, A., Tanniou, A., Stiger-Pouvreau, V., Widowati, I., Bedoux, G. & Bourgougnon, N. 2013. Biochemical and antiviral activities of enzymatic hydrolysates from different invasive French seaweeds. *J. Appl. Phycol.* 26: 1029-1042. doi: 10.1007/s10811-013-0201-6.
- Harrison, P.J & Berges, J.A. 2005. Marine Culture Media. In. *Algal Culturing Techniques*. (Ed) R.A. Andersen. 1<sup>st</sup> Ed. Burlington: Elsevier Academic Press. 578 p.
- Hoai Thu, N.T., Lan Anh, H.T., Hien Hoang, M., Kim, D.D. & Hong, D.D. 2015. Study on Biological Characteristics of a Newly Isolated Vietnamese Strain of Microalga *Isochrysis galbana* Parke for Utilizing as Live Aquaculture Feed. *Russian. J. Mar. Biol.* 41 (3): 203-211. doi: 10.1134/S1063074015030074.
- Khatoon, H., Abdu Rahman, N., Banerjee, S., Harun, N., Suleiman, S.S., Nur Zakaria, N.H., Lananan, F., Abdul, S.H., Hamid & Endut, A. 2014. Effects of different salinities and pH on the growth and proximate composition of *Nannochloropsis* sp. and *Tetraselmis* sp. isolated from South China Sea cultured under control and natural condition. *Int. Biodet. Biodeg.*, 95: 11-18. doi: 10.1016/j.ibiod.2014.06.022.
- Kokou, F., Makridis, P., Kentouri, M. & Divanach, P. 2012. Antibacterial activity in microalgae cultures. *Aquacul. Res.*, 43: 1520-1527. doi: 10.1016/j.aquacul.2011.02.955.x.
- Lavens, P. & Sorgeloos, P. 1996. Manual on the production and use of live food for aquaculture. Rome: FAO Fisheries Technical Paper.
- Mishra, S.K., Shrivastav, A., Maurya, R.R., Patidar, S.K., Haldar, S. & Mishra, S. 2012. Effect of light quality on the C-phycoerythrin production in marine cyanobacteria *Pseudanabaena* sp. isolated from Gujarat coast, India. *Protein. Expr. Purif.* 80: 234-238. doi: 10.1016/j.pep.2011.08.011.
- Mohammadi, M., Kazeroni, N. & Baboli, M.J. 2015. Fatty acid composition of the marine microalga *Tetraselmis chuii* Butcher in response to culture conditions. *J. Algal. Biomass. Utiln.* 6 (2): 49-55.
- Molina-Cárdenas, C.A., del P. Sánchez-Saavedra, M & Lizárraga-Partida, M.L. 2014. Inhibition of pathogenic *Vibrio* by the microalgae *Isochrysis galbana*. *J. Appl. Phycol.* 26: 2347-2355. doi: 10.1007/s10811-014-0270-1.
- Najdenski, H.M., Gigova, L.G., Iliev, I.I., Pilarski, P.S., Lukavsky, J., Tsvetkova, I.V., Ninova, M.S. & Kussovski, V.K. 2013. Antibacterial and antifungal activities of selected microalgae and cyanobacteria. *Int. J. Food. Sci. Technol.* 48: 1533-1540. doi: 10.1111/ijfs.12122.
- Nalder, T.D., Miller, M.R. & Packer, M.A. 2015. Changes in lipid class content and composition of *Isochrysis* sp. (T-Iso) grown in batch culture. *Aquacult Int.* 23(5): 1293-1312. doi: 10.1007/s10499-015-9884-9.
- Ozdemir, G., Karabay, N.U., Dalay, M.C. & Pazarbasi, B. 2004. Antibacterial activity of volatile component and various extracts of *Spirulina platensis*. *Phytother. Res.*, 18: 754-757. doi: 10.1002/ptr.1541.
- Plaza, M., Santoyo, S., Jaime, L., García-Blairsy, R.G., Herrero, M., Señoráns, F.J. & Ibáñez, E. 2010. Screening for bioactive compounds from algae. *J. Pharm. Biomed. Anal.* 51(2): 450-455. doi: 10.1016/j.jpba.2009.03.016.
- Pradhan, J., Das, P.K., Sahu, S., Marhual, N.P., Swain, A.K., Mishra, B.K. & Eknath, A.E. 2011. Traditional antibacterial activity of freshwater microalgae *Spirulina platensis* to aquatic pathogens. *Aquacul. Res.* 43: 1287-1295.
- Rajendran, N., Selvan, B.K., Piriya, P.S., Logeswari, V., Kathiresan, E., Tamilselvi. A. & John Vennison, S.J. 2014. Phytochemicals, Antimicrobial and Antioxidant Screening From Five Different

- Marine Microalgae. *J. Chem. Pharm. Sci.* 7(2): 78-85.
- Radjasa, O. K., Limantara, L. & Sabdono, A. 2009. Antibacterial activity of a pigment producing bacterium associated with *Halimeda* sp. from Land-Locked marine Lake Kakaban, Indonesia. *J. Coast. Dev.* 12 (2): 100-104
- Smith, V. J., Desbois, A.P. & Dyrinda, E.A. 2010. Conventional and unconventional antimicrobials from fish, marine invertebrates and microalgae. *Marine Drugs.* 8: 1213-1262. doi:10.3390/md8041213.
- Susilowati, R., Sabdono, A. & Widowati, I. 2015. Isolation and characterization of bacteria associated with brown algae *Sargassum* spp. from Panjang island and their antibacterial activities. *Procedia. Env. Sci.* 23: 240-246. doi: 10.1016/j.proenv.2015.01.036.
- Trianto, A., Hermawan, I., Suzuka, T. & Tanaka, J. 2011. Two new cytotoxic *Candida spongiolides* from an Indonesian Sponge. *ISRN Pharm.*, 852619. doi: 10.5402/2011/852619.
- Widowati, I., Daphné, L., Puspita, M. & Bourgougnon, N. 2014. Antibacterial and Antioxidant Properties of the Red Alga *Gracillaria verrucosa* from the North Coast, Java, Semarang, Indonesia. *Int. J. Latest Res. Sci. Technol.*, 3(3): 179-185
- Widowati, I., Zainuri, M., Kusumaningrum, H.P., Susilowati, R., Hardivillier, Y., Leignel, V., Bourgougnon N. & Mouget, J.L. 2017. Antioxidant activity of three microalgae *Dunaliella salina*, *Tetraselmis chuii* and *Isochrysis galbana* clone Tahiti. *IOP Conference Series: Earth and Environmental Science* 55: 012067, doi: 10.1088/1755-1315/55/1/012067.

# Antibacterial Activity of Microalgae *Dunaliella salina*, *Tetraselmis chuii* and *Isochrysis galbana* Against Aquatic Pathogens

---

## ORIGINALITY REPORT

---

19%

SIMILARITY INDEX

%

INTERNET SOURCES

19%

PUBLICATIONS

%

STUDENT PAPERS

---

## PRIMARY SOURCES

---

- 1** Becker, E. Wolfgang. "Microalgae for Aquaculture: Nutritional Aspects", Handbook of Microalgal Culture Applied Phycology and Biotechnology, 2013. 3%

Publication
  - 2** Najdenski, Hristo M., Liliana G. Gigova, Ivan I. Iliev, Plamen S. Pilarski, Jaromir Lukavský, Iva V. Tsvetkova, Mariana S. Ninova, and Vesselin K. Kussovski. "Antibacterial and antifungal activities of selected microalgae and cyanobacteria", International Journal of Food Science & Technology, 2013. 3%

Publication
  - 3** E. M. Fawzy, M. E. Soltan, S. M. Sirry. "Mobilization of different metals between parts and their crystal salts – soil system at the banks of river Nile, Aswan, Egypt ", Toxicological & Environmental Chemistry, 2006 2%

Publication
-



4

Ocky Karna Radjasa, Siti Isrina Oktavia Salasia, Agus Sabdono, Jutta Weise et al. "Antibacterial Activity of Marine Bacterium Pseudomonas sp. Associated with Soft Coral Sinularia polydactyla against Streptococcus equi Subsp. zooepidemicus", International Journal of Pharmacology, 2007

Publication

2%

5

Pradhan Jyotirmayee, Das Sachidananda, Kumar Das Basanta. "Antibacterial activity of freshwater microalgae: A review", African Journal of Pharmacy and Pharmacology, 2014

Publication

2%

6

Ngo Thi Hoai Thu, Hoang Thi Lan Anh, Minh Hien Hoang, Dang Dinh Kim, Dang Diem Hong. "Study on biological characteristics of a newly isolated Vietnamese strain of microalga Isochrysis galbana Parke for utilizing as live aquaculture feed", Russian Journal of Marine Biology, 2015

Publication

1%

7

Soad M. Mohy El-Din, Amani M.D. El-Ahwany. " Bioactivity and phytochemical constituents of marine red seaweeds ( , and ) ", Journal of Taibah University for Science, 2018

Publication

1%

8

Susana Santoyo, Miguel Herrero, F. Javier Señorans, Alejandro Cifuentes, Elena Ibáñez,

1%

Laura Jaime. "Functional characterization of pressurized liquid extracts of *Spirulina platensis*", European Food Research and Technology, 2006

Publication

---

9

Ceres A. Molina-Cárdenas, M. del Pilar Sánchez-Saavedra, Marcial L. Lizárraga-Partida. "Inhibition of pathogenic *Vibrio* by the microalgae *Isochrysis galbana*", Journal of Applied Phycology, 2014

Publication

---

1 %

10

Saida Lökk, Veljo Kisand. "Microbiological characteristics and sanitary status of Lake Peipsi-Pihkva and its inflows in 1980s", Hydrobiologia, 1996

Publication

---

1 %

11

Luis Miguel Serrano-Bermúdez, Luis Carlos Montenegro-Ruíz, Rubén Darío Godoy-Silva. "Effect of CO<sub>2</sub>, aeration, irradiance, and photoperiod on biomass and lipid accumulation in a microalga autotrophically cultured and selected from four Colombian-native strains", Bioresource Technology Reports, 2020

Publication

---

<1 %

12

Microbial Diversity and Biotechnology in Food Security, 2014.

Publication

---

<1 %

13

"Microbial Diversity in Ecosystem Sustainability and Biotechnological Applications", Springer Science and Business Media LLC, 2019

Publication

---

<1 %

14

Abhilasha Shourie, U. Vijayalakshmi, Anamika Singh. "Bioactive compounds from microalgae", Elsevier BV, 2022

Publication

---

<1 %

15

Aseer Manilal. "Virulence of Vibrios Isolated from Diseased Black Tiger Shrimp, Penaeus monodon, Fabricius", Journal of the World Aquaculture Society, 06/09/2010

Publication

---

<1 %

16

Mohd Azmuddin Abdullah, Hanaa Ali Hussein. "Integrated algal and oil palm biorefinery as a model system for bioenergy co-generation with bioproducts and biopharmaceuticals", Bioresources and Bioprocessing, 2021

Publication

---

<1 %

17

Benan İnan, Didem Özçimen. "Preparation and characterization of microalgal oil loaded alginate/poly (vinyl alcohol) electrosprayed nanoparticles", Food and Bioproducts Processing, 2021

Publication

---

<1 %

18

I. Rodríguez-Meizoso, L. Jaime, S. Santoyo, A. Cifuentes, G. García-Blairsy Reina, F. J. Señoráns, E. Ibáñez. "Pressurized Fluid Extraction of Bioactive Compounds from Phormidium Species", Journal of Agricultural and Food Chemistry, 2008

Publication

&lt;1 %

19

Wagih Abd El-Fattah Elshouny, Mostafa Mohammed El-Sheekh, Shawky Zaki Sabae, Maha Abdelfattah Khalil, Hanaa Mohamed Badr. "ANTIMICROBIAL ACTIVITY of SPIRULINA PLATENSIS AGAINST AQUATIC BACTERIAL ISOLATES", Journal of Microbiology, Biotechnology and Food Sciences, 2017

Publication

&lt;1 %

20

Gerusa N.A. Senhorinho, Gregory M. Ross, John A. Scott. "Cyanobacteria and eukaryotic microalgae as potential sources of antibiotics", Phycologia, 2019

Publication

&lt;1 %

21

Merichel Plaza, Miguel Herrero, Alejandro Cifuentes, Elena Ibáñez. "Innovative Natural Functional Ingredients from Microalgae", Journal of Agricultural and Food Chemistry, 2009

Publication

&lt;1 %

---

Exclude quotes      On

Exclude matches      Off

Exclude bibliography      On

# Antibacterial Activity of Microalgae *Dunaliella salina*, *Tetraselmis chuii* and *Isochrysis galbana* Against Aquatic Pathogens

---

GRADEMARK REPORT

---

FINAL GRADE

**/0**

GENERAL COMMENTS

**Instructor**

---

PAGE 1

---

PAGE 2

---

PAGE 3

---

PAGE 4

---

PAGE 5

---

PAGE 6

---