

SOFT CORAL *Sinularia* *gibberosa* EXTRACTS ORIGIN PALU BAY, CENTRAL SULAWESI WITH ANTIBACTERIAL AND ANTIOXIDANT ACTIVITY

by Putut Har Riyadi

Submission date: 18-Mar-2022 10:55AM (UTC+0700)

Submission ID: 1786861804

File name: 33838-120291-3-PB.pdf (907.75K)

Word count: 8013

Character count: 44443

SOFT CORAL *Sinularia gibberosa* EXTRACTS ORIGIN PALU BAY, CENTRAL SULAWESI WITH ANTIBACTERIAL AND ANTIOXIDANT ACTIVITY

Muliadin¹, Didit Kustantio Dewanto¹, Roni Hermawan¹, Putut Har Riyadi² and Wendy Alexander Tanod^{3*}

¹Institute of Fisheries and Marine (Sekolah Tinggi Perikanan dan Kelautan – STPL Palu), Palu,

Jalan Soekarno Hatta KM. 6 Kampus Madani, Mantikulore, Palu, 94118 Central Sulawesi, Indonesia

²Department of Fisheries Post Harvest Technology, Faculty of Fisheries and Marine Science, Universitas Diponegoro,

Jalan Prof. Soedarto, SH Tembalang, Semarang, 50275 Central Java, Indonesia

³Department of Fisheries and Marine, Politeknik Negeri Nusa Utara,

Jalan Kesehatan No.1, Sawang Bendera, Tahuna, 95812 Sangihe Archipelago, North Sulawesi, Indonesia

E-mail: wendytanod@gmail.com

Received : 30 October 2020 , Accepted : 31 January 2021

ABSTRACT

Sinularia gibberosa is one of the soft coral species reported to produce bioactive compounds for pharmaceutical's potential. Soft corals produce compounds with antibacterial and antioxidant properties. This study aimed to obtain a bioactive profile of *S. gibberosa*, which could scavenge DPPH radicals and inhibit the growth of *Listeria monocytogenes*, *Pseudomonas aeruginosa*, and *Salmonella typhimurium*. The research included a sampling of soft corals, extraction by maceration, identification of chemical profiles using LC-HRMS, the assay for antibacterial activity (well-diffusion method), antioxidant assay (DPPH method), and total phenolic content (Folin-Ciocalteu method). Sampling was conducted in Palu Bay, Central Sulawesi, Indonesia. Based on monomorphic colonies and sclerites, soft coral samples were identified as *Sinularia gibberosa*. The chemical profiles of *S. gibberosa* extracts was dominated by trimethylethanolamine (22.03%), arachidonic acid (14.13%), (3R)-3-hydroxy-4-(trimethylazaniumyl)-butanoate (10.90%), (5Z,8Z,11Z,14Z,16R)-16-Hydroxy-5,8,11,14-icosatetraenoic acid (5.64%), Octyl decyl phthalate (4.18%), and N-Methylnicotinic acid (3.63%). The antibacterial assaying at 300 mg/mL of *S. gibberosa* extracts showed moderate to strong antibacterial activity, with the inhibition zone diameter of *L. monocytogenes* (15.11 ± 0.70 mm), *P. aeruginosa* (13.44 ± 0.84 mm), and *S. typhimurium* (19.78 ± 0.39 mm). *S. gibberosa* extracts showed strong antioxidant activity, with an IC_{50} of 54.69 ± 0.34 μ g/mL and total phenolic content was 5423.76 ± 14.00 mg GAE/25 mg dry extract. Based on the results, *S. gibberosa* shows the potential for antibacterial and antioxidant activity. This study indicates that soft corals origin Palu Bay, Central Sulawesi, Indonesia, are potential organisms in the discovery and development of antibacterial and antioxidant agents.

Keywords: Bioactive compounds; *Listeria monocytogenes*, soft coral, *Pseudomonas aeruginosa*, and *Salmonella typhimurium*

INTRODUCTION

Indonesia's marine biodiversity is very high and has significant potential in the economy (Supriharyono, 2000). Biodiversity is directly proportional to the diversity of natural products isolated from organisms. The bioprospection of natural compounds from the marine environment has produced thousands of active compounds with pharmacological functions. Thousands of active compounds produced by marine organisms confirm that marine organisms are an important source for the research and development of new drugs (Tanod *et al.*, 2015).

Eastern Indonesian waters are waters with high biodiversity of marine organisms (Tapilatu, 2015). Based on this, eastern Indonesia's waters can become the center for discovering potential bioactive from marine organisms (Leal *et al.*, 2012). Marine organisms have physiologically unique metabolites to survive in extreme marine environments. The unique metabolites of marine organisms are chemically and biologically beneficial and not produced by terrestrial organisms (Blunt *et al.*, 2013). Soft corals contain various bioactive substances and have antibacterial and antioxidant biological activities (Bishara *et al.*, 2007; Ishii *et al.*, 2009). There have been many explorations of the search for pharmacological agents from Indonesian waters. However,

the investigation of bioactive substances from soft corals from Sulawesi waters has not been widely carried out, especially uncovering the antibacterial and antioxidant potential.

Soft coral genus *Sinularia* is one of the genera reported to produce many bioactive compounds and has enormous potential in pharmacology (Byju *et al.*, 2015). *Sinularia* was reported to produce flavonoids, saponins, alkaloids, steroids, phenolics and triterpenoids (Tanod *et al.*, 2019a; Salanggon *et al.*, 2020). Romansyah (2011) reported that soft corals could produce compounds that can be used as antibacterial and antioxidant agents. Antibacterial are substances that can kill or inhibit bacterial growth. The need for active antibacterial agents continues to increase (Wright and Sutherland, 2007). The World Health Organization reports the increasing resistance of pathogenic bacteria to available antibacterial active agents (Rice, 2008; Radić and Strkelj, 2012). Antioxidants are substances that function to protect cells from damage caused by free radicals. Antioxidant substances can scavenge reactive oxygen species (ROS) to prevent oxidative stress in cells (Liu *et al.*, 2015).

Previous research has reported the pharmacological potential of soft corals from Palu Bay, namely as an antibacterial against the growth of *Escherichia coli*, *Staphylococcus aureus* (Tanod *et al.*, 2018a; Tanod *et al.*, 2019b), and *Pseudomonas aeruginosa* (Salanggon *et al.*,

2020); antioxidants by DPPH method (Dewanto *et al.*, 2019; Tanod *et al.*, 2019c); antifeedant to inhibit feeding activity of *Plutella xylostella* larvae (Tanod *et al.*, 2018b); and nitric oxide and nuclear factor kappa beta inhibitors (Riyadi *et al.*, 2019; Tanod *et al.*, 2019a). However, the chemical profiles of the soft coral extract has not been identified. In addition, research on the antibacterial activity of *Sinularia* only observed the inhibitory growth of *E. coli* and *S. aureus*. Even though many pathogenic bacteria threaten human health, this study aimed to obtain a chemical profile of *Sinularia gibberosa*, which can scavenge DPPH radicals and inhibit the

growth of *Listeria monocytogenes*, *Pseudomonas aeruginosa*, and *Salmonella typhimurium*.

RESEARCH METHODS

Study Area

The Palu Bay is a semi-closed water area located in Central Sulawesi, Indonesia, and borders the Makassar Strait. A sampling of *S. gibberosa* from Palu Bay's coastal area in Lero, Donggala, Central Sulawesi, Indonesia at coordinates 0°37'44.76" South Latitude and 119°48'40.60" East Longitude (Figure 1).

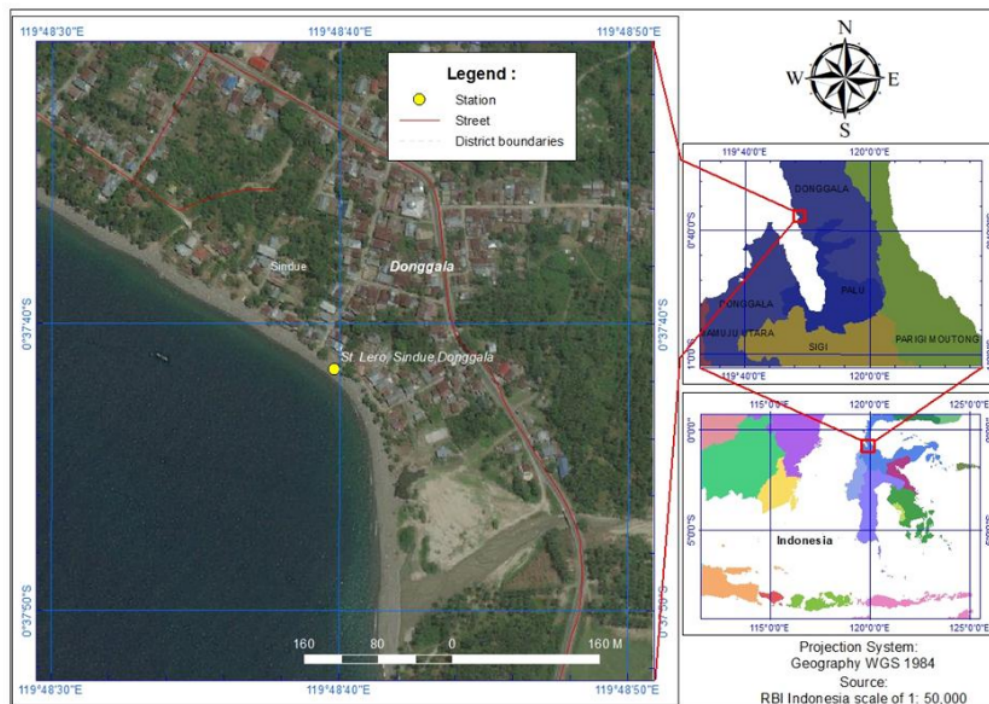


Figure 1. Sampling Location of *Sinularia gibberosa* at Lero, Central Sulawesi, Indonesia

Chemical and Reagents

Nutrient agar (Merck), nutrient broth (Merck), bacteriological agar (Hi-media), dichloromethane (Merck), methanol (Merck), 1,1-Diphenyl-2-picrylhydrazyl, free radical (DPPH, Merck), Folin-Ciocalteu reagent, gallic acid, Na_2CO_3 , and aquadest were purchased from CV. Amani Media Malang and CV. Intraco Makassar, Indonesia.

Animal Materials

A sampling of *S. gibberosa* soft corals was carried out in July 2020 with sunny weather conditions and hot sunlight. Sampling using SCUBA at a depth of 5-6 m. Soft corals identified using instructions Fabricus and Alderslade (2001) by observing the form of monomorphic colonies and interior sclerites. Soft coral was cut into smaller sizes and stored in the freezer before extraction. Soft coral samples were kept at the Institute of Fisheries and Marine (Sekolah Tinggi Perikanan dan Kelautan-STPL Palu).

Extraction

A total of 500 g of *S. gibberosa* samples were dried using an oven (Finco OV50) at 60°C during 25-30 hours. After drying, the sample mashed until it becomes flour. Then 100 g of *S. gibberosa* flour macerated in methanol:dichloromethane (1:1) for 48 hours (Hsiao *et al.*, 2015; Putra *et al.*, 2016a). After that, the extracts filtered and dried with a rotary vacuum evaporator (EYELA N-1100). The maceration process was carried out three times. Then, the dried extracts that have been weighed and stored in the refrigerator.

Chemical Profiles Screening

Chemical profiles screening of *S. gibberosa* extracts using Liquid Chromatography and High-Resolution Mass Spectrometry (LC-HRMS) with an injection volume of 1 μL . Bioactive profile analysis was performed using the LC-HRMS Shimadzu-8040, Japan, equipped with an autosampler, binary pump, column compartment, and a diode array detector for

scanning spectroscopy. Chromatographic separation was performed using a C-18 column, Shim Pack FC-ODS (2 mm ϕ x 150 mm, 3 μ m). Two solvents prepared included solvent A (H₂O:MeOH, 8:2) with 0.1% formic acid and solvent B (0.1% formic acid in acetonitrile). The two solvents were adjusted to 95:5 ratios, respectively, with an elution gradient of 0/0 at 0 minutes, 15/85 at 5 minutes, 20/80 at 20 minutes, 90/10 at 24 minutes. Mass spectroscopy (MS) analysis was performed by Electrospray Ionization (ESI) with positive ions as the source. MS data were obtained through collision energy traps starting at 5.0 V. The ESI source parameters were regulated, including a capillary voltage of 3.0 kV, source temperature of 100°C, desolvation temperature of 350°C, sampling cone 23 V, and desolvation gas flow of 6 L / hour. The chromatogram data obtained were compared with the data profile from the mzCloud Library system.

Antibacterial Assay

The antibacterial assay used the well-diffusion method on a petri dish, as shown by Balouri *et al.* (2016); Alhaddad *et al.*, (2019), with modifications. The modification was carried out by adding a 2 g nutrient agar composition with 2 g of bacteriological agar in 100 mL of aquadest as the base medium layer. The well-diffusion method used two media layers: the base media and the seed media layers. The base media was made by dissolving nutrient agar and bacteriological agar, then sterilizing it and pouring it into a petri dish. The seed medium layer was made from 70% nutrient agar in 100 mL of aquadest, then put into a glass tube containing 9 mL and sterilized.

Furthermore, 1 mL of warm seed medium was added to the test bacteria with a density of 1×10^7 colony/mL (bacterial solution compared to the standard McFarland-Hi-media solution). Isolates *Listeria monocytogenes* ATCC 49594, *Salmonella typhimurium* ATCC 13311, and *Pseudomonas aeruginosa* ATCC 27853 were obtained from the Laboratory of Microbiology, Faculty of Medicine, University of Brawijaya Malang, Indonesia. The seed medium that has been added with the test bacteria was vortexed. Then it is poured over the base media layer. After the media hardens slightly, a well-hole was made at a certain distance. Each well was filled with 50 μ L of *S. gibberosa* extracts at concentrations of 50, 100, 200, 300, 400 mg/mL, and incubated at 37°C for 24 hours. Ciprofloxacin 10 mg/mL and Pine Oil 1% were used as comparison controls. After that, the zone of inhibition was observed and measured. All experimental measurement data were carried out in three replications and expressed as Mean \pm Standard Deviation ($n = 3$). The results of the inhibition zone measurement evaluated by the minimum inhibitory concentration (MIC) and Minimum Bactericidal Concentration (MBC) using the Bloomfield method (Bloomfield, 1991). The MIC value was determined by plotting the (ln) extract concentration on the x-axis, while the y-axis is the inhibition zone's squared value. The linear regression $y = a + bx$ with the x-axis as the value for Mt. The MIC value is $0.25 \times Mt$ and the MBC value is $4 \times MIC$.

Antioxidant Assay

Antioxidant activity was determined using the DPPH free radical scavenging method (Molyneux, 2004; Dewanto *et al.*, 2019). A total of 25 mg of *S. gibberosa* extracts was placed in a glass tube. Then, 125 mL of ethanol was added to obtain a 200 μ g/mL extract. After that, serial dilutions of 20, 40, 60, 80,

100 μ g/mL were made. A 2 mL aliquot of the extract solution of each concentration was added to 2 mL of the 50 μ M DPPH solution. The mixture was homogenized and left for 30 minutes in a dark room at room temperature before measuring the free radical absorption at a wavelength of 517 nm with a Spectrophotometer (UV-VIS spectrophotometer T90 + PG Instruments Ltd). The absorbance value of the DPPH solution was also measured and determined by IC₅₀ (The half maximal inhibitory concentration). Vitamin E was used as a control. Then, the percentage of inhibition was plotted on the y-axis and the x-axis as a series of dilutions of the extract concentrations to obtain a linear regression equation ($y = a + bx$). IC₅₀ was determined as the concentration of the extract solution required to scavenge 50% DPPH free radicals. The assay was carried out in three repetitions, and the measurement results were expressed with a standard deviation. The percentage inhibition of the sample was calculated using the equation:

$$\text{DPPH Scavenging Effect (\%)} = \frac{\text{Blank Absorbance} - \text{Sample Absorbance}}{\text{Blank Absorbance}} \times 100 \quad (1)$$

Total Phenolic Assay

The *S. gibberosa* extracts were evaluated for the total phenol content according to the Folin-Ciocalteu method (Blainski *et al.*, 2013; Lamuela-Raventós, 2017; Dewanto *et al.*, 2021). The first stage was making a standard curve of gallic acid, which is as much as 25 mg of gallic acid was weighed, then dissolved in EtOH:H₂O (1:1) to a volume of 25 mL. Gallic acid solutions were made in a series of dilution concentrations of 5, 20, 40, 60, 80, and 100 mg/L. From each dilution concentration, 1 mL of gallic acid was taken, and 10 mL of aquadest was added. Then 1 mL of Folin-Ciocalteu reagent (homogenization) was added. After that, let stand for 8 minutes, then add 3 mL of 20% Na₂CO₃ solution (homogenization). Then let stand for 2 hours at room temperature. The absorbance value was measured at a wavelength of 750 nm. The standard curve for gallic acid was prepared with gallic acid (mg/L) with an absorbance value.

In the second stage, 25 mg of *S. gibberosa* extracts dissolved in 25 mL of EtOH:H₂O (1:1) solution. Then from the extract solution, 1 mL was taken, and 10 mL of aquadest + 1 mL of Folin-Ciocalteu reagent (homogenization) was added. After that, let stand for 8 minutes and add 3 mL of 20% Na₂CO₃ (let stand for 2 hours at room temperature). The absorption was then measured with a UV-Vis spectrophotometer at a wavelength of 750 nm, which gives a blue color. The total phenolic was determined using the standard curve regression equation for gallic acid.

RESULT AND DISCUSSION

Based on monomorphic colonies, the soft coral sample used in this study was identified as *Sinularia gibberosa* (presented in Figure 2). Soft coral identification procedures follow directions Fabricus and Alderslade (2001). *S. gibberosa* has low-sized colonies with small protruding protrusions, branching, and colonies covering tens of square meters. *S. gibberosa* has monomorphic retraction and small polyps. *S. gibberosa* has short tentacles, hard lobules, is round and small in size. The surface sclerites of *S. gibberosa* are club-shaped, and the interior sclerites are spindles. The sclerite is a spindle, unbranched, and colorless.

The results of screening the bioactive profile of *S. gibberosa* extracts using LC-HRMS detected 154 peaks (113 compounds), with a retention time range of 0.947 - 26,421 min. However, only 36 peaks (29 compounds) were above 85% quality. The chemical profiles screening of *S. gibberosa* extracts was dominated by fatty acid derivatives, such as arachidonic acid, docosahexaenoic acid ethyl ester, and eicosapentaenoic acid. Soft corals produce more than 5800 secondary metabolites, including fatty acid derivatives with rare and unusual structures (Ermolenko *et al.*, 2020). Imbs *et al.* (2007) reported the presence of fatty acid compounds such as arachidonic acid and phthalates from *Sinularia* sp. Characteristic of fatty acid structure have a carboxyl and

hydroxyl group. Previous studies have reported several fatty acid derivatives of *S. gibberosa*, such as sinularolides (Li *et al.*, 2005); gibberoketosterols (Ahmed *et al.*, 2006); Sinugibberosides (Chen *et al.*, 2006); and gibberosenes (Ahmed *et al.*, 2008).

Kabara *et al.* (1972); Do Nascimento *et al.* (2014) reported that fatty acid derivatives showed antibacterial and antioxidant activity. Fatty acid derivatives from marine organisms have also been reported to exhibit antibacterial and antioxidant properties (Karthikeyan *et al.*, 2014; Liu *et al.*, 2019; Alves *et al.*, 2020). The screening results for the chemical profiles of *S. gibberosa* extracts with LC-HRMS could be seen in Table 1.

Table 1. Screening of the Chemical Profiles of *Sinularia gibberosa* Extracts with LC-HRMS

No	Chemical Profile	Molecular Formula	RT (min)	Area (%)	Quality	PubChem CID
1	(+/-)-8-Hydroxy-5Z,9E,11Z,14Z,17Z-eicosapentaenoic acid	C ₂₀ H ₃₀ O ₃	16.810	0.30	90.9	16061128
2	4-Methylene-2-octyl-5-oxotetrahydro-3-furancarboxylic acid	C ₁₄ H ₂₂ O ₄	8.905	0.09	90.4	4248455
3	(5Z,8Z,11Z,14Z,16R)-16-Hydroxy-5,8,11,14-icosatetraenoic acid	C ₂₀ H ₃₂ O ₃	17.689	5.64	93.5	9548884
4	19-Nortestosterone	C ₁₈ H ₂₆ O ₂	15.746	0.26	87.2	9904
5	2,3-Dinor-8-epi-prostaglandin F2 α	C ₁₈ H ₃₀ O ₅	16.005	0.08	86.7	9548881
6	(10E,12Z)-9-Oxo-10,12-octadecadienoic acid	C ₁₈ H ₃₀ O ₃	18.196	0.15	89.5	9839084
7	7H-Purin-6-amine	C ₅ H ₅ N ₅	1.227	0.58	88.8	190
8	Arachidonic acid	C ₂₀ H ₃₂ O ₂	21.475 22.010	14.13	89.7 88.4	444899
9	Trimethylaminoacetic acid	C ₅ H ₁₂ NO ₂	26.386	0.20	86.7	247
10	Bis(2-ethylhexyl) phthalate	C ₂₄ H ₃₈ O ₄	23.310	0.12	90.8	8343
11	Bis(2-ethylhexyl) adipate	C ₂₂ H ₄₂ O ₄	23.310	0.24	85.4	7641
12	Trimethylethanolamine	C ₅ H ₁₃ NO	1.006 1.221 11.615	22.03	94.1 94.1 87.9	305
13	Dibutyl phthalate	C ₁₆ H ₂₂ O ₄	18.313	0.47	88.8	3026
14	Docosahexaenoic acid ethyl ester	C ₂₄ H ₃₆ O ₂	19.651	1.19	88.6	9831416
15	Eicosapentaenoic acid	C ₂₀ H ₃₀ O ₂	17.486	1.40	93.2	446284
16	Eicosapentaenoic acid methyl ester	C ₂₁ H ₃₂ O ₂	19.871 20.100	0.26	91.3 91.3	6421261
17	Erucamide	C ₂₂ H ₄₃ NO	22.504	0.13	95.0	5365371
18	Hexadecanamide	C ₁₆ H ₃₃ NO	22.658	0.41	94.0	69421
19	(3R)-3-hydroxy-4-(trimethylazaniumyl)butanoate	C ₇ H ₁₅ NO ₃	0.967 1.205	10.90	90.6 90.6	10917
20	3-Methylcyclopentadecanone	C ₁₆ H ₃₀ O	20.877	0.12	85.5	10947
21	Nicotinic acid	C ₆ H ₅ NO ₂	1.445 23.831	0.04	85.5 86.8	938
22	Octyl decyl phthalate	C ₂₆ H ₄₂ O ₄	24.085 24.552	4.18	87.3 88.5	8380
23	Oleamide	C ₁₈ H ₃₅ NO	22.090	1.43	96.4	5283387
24	Oleoyl ethanolamide	C ₂₀ H ₃₉ NO ₂	22.385	0.14	85.6	5283454
25	Palmitoyl ethanolamide	C ₁₈ H ₃₇ NO ₂	20.995	0.16	87.2	4671
26	Pinolenic acid	C ₁₈ H ₃₀ O ₂	17.473	0.16	92.9	5312495
27	Stearamide	C ₁₈ H ₃₇ NO	24.644	0.21	87.6	31292
28	Thymine	C ₅ H ₆ N ₂ O ₂	1.556	0.53	92.0	1135
29	N-Methylnicotinic acid	C ₇ H ₇ NO ₂	0.947	3.63	95.7	5571



Figure 2. *Sinularia gibberosa* Collected from Palu Bay, Central Sulawesi, Indonesia

Evaluation of antibacterial activity was carried out by observing the growth inhibition of *Listeria monocytogenes*, *Salmonella typhimurium*, and *Pseudomonas aeruginosa*. The inhibition zone diameter of *S. gibberosa* extracts effect can be seen in Figure 3. In comparison, the measurement results of the control inhibition zone diameter are presented in Figure 4.

The *S. gibberosa* extracts showed varying inhibition zone diameters against the growth of *L. monocytogenes*, *S. typhimurium*, and *P. aeruginosa*. According to the inhibition zone category by Paudel *et al.* (2014), there are four categories of antibacterial activity: very strong (inhibition zone $\phi > 20$ mm), strong (inhibition zone, $\phi 15 - 20$ mm), moderate (inhibition zone $\phi 10 - 15$ mm), and weak (inhibition zone $\phi < 10$ mm). Extracts of *S. gibberosa* showed antibacterial potential from very strong to weak against *L. monocytogenes*, *S. typhimurium*, and *P. aeruginosa*, depending on the extract concentration.

Figure 3 showed that the 100 and 200 mg/mL extracts of *S. gibberosa* had moderate antibacterial activity against *S. typhimurium*, whereas against *L. monocytogenes* and *P. aeruginosa* showed weak to moderate antibacterial activity. *S. gibberosa* extracts 300 mg/mL showed moderate to strong antibacterial activity. While the 400 mg/mL *S. gibberosa* extracts showed very strong antibacterial activity against *S. typhimurium* and *P. aeruginosa*, because it was able to form an inhibition zone diameter > 20 mm. While *S. gibberosa* extracts, 400 mg/mL showed strong antibacterial activity against *L. monocytogenes*.

Based on the MIC and MBC, *S. gibberosa* extracts are more effective at inhibiting Gram-negative than Gram-positive bacteria. Compounds with carboxyl groups that are thought to act as antibacterials. The carboxyl group was reported to affect antibacterial activity (Maggi *et al.*, 1968; Zi *et al.*, 2018). The MIC and MBC evaluation of *S. gibberosa* extracts against three tested bacteria were presented in Table 2.

Previous research reports on the antibacterial potential of the genus *Sinularia*, namely *S. polydactyla* collected from the Red Sea, showed the potential to inhibit *S. aureus* (Afifi *et al.*, 2016). *Sinularia* sp. collected from Lampung, Indonesia has the potential to inhibit *Bacillus subtilis*, *E. coli*, *S. aureus*, and *Vibrio eltor* (Putra *et al.*, 2016b). *Sinularia* sp. from Bandar Al-Khayran, Oman, can inhibit *B. subtilis*, *E. coli*, *Micrococcus luteus*, *S. aureus*, and *Salmonella* sp. (Dobretsov *et al.*, 2015). *S. kavarattiensis* collected by the coast of

Mandapam, India, can inhibit *S. aureus* and *Staphylococcus epidermidis* (Rajaram *et al.*, 2014). *S. depressa* from Lingshui Bay, China, was reported to inhibit *S. aureus* (Liang *et al.*, 2013). *S. gibberosa* collected from Pingtung Beach, Southern Taiwan was reported to exhibit the better inhibitory activity of *B. subtilis* than ampicillin (Lin *et al.*, 2013). *S. humilis*, collected from the South China Sea, showed activity against *Bacillus megaterium* (Sun *et al.*, 2012).

Assaying for antibacterial activity in this study used Ciprofloxacin 10 mg/mL and Pine Oil 1% as a control (Figure 4). Ciprofloxacin is an antibacterial agent that is very stable and diffuses well on agar media. Antimicrobial activity is influenced by factors such as pH and media composition, the number of inoculums, the stability of antimicrobial compounds, incubation time, and microorganisms' metabolic activity (Jawetz *et al.*, 2005). Ciprofloxacin is an antibacterial agent with a spectrum of activity covering most pathogenic bacteria (Jin *et al.*, 2019). Ciprofloxacin is effective against Gram-negative bacteria (such as *E. coli*, *Haemophilus influenzae*, *Klebsiella pneumoniae*, *Legionella pneumophila*, *Moraxella catarrhalis*, *Proteus mirabilis*, and *P. aeruginosa*), but less effective against Gram-positive bacteria (such as *S. aureus*, *Streptococcus pneumoniae*, and *Enterococcus faecalis*) (Marfuati *et al.*, 2017). Meanwhile, Fekih *et al.* (2014); Tillah *et al.* (2017) reported that pine oil from pine extracts provides antibacterial effects against *L. monocytogenes*, *Enterococcus faecalis*, *P. aeruginosa*, *Acinetobacter baumannii*, *Citrobacter freundii*, *S. aureus* and *K. pneumoniae*.

The *S. gibberosa* extracts were also evaluated for its antioxidant activity using the DPPH radical scavenging method. The DPPH purple light intensity level is proportional to the decrease in the DPPH concentration. This reduction is caused by the reaction of the hydrazine diphenyl-2-picryl molecule with the hydrogen atoms released by the sample molecule components so that the hydrazine diphenyl picryl compound is formed and causes DPPH to change color from purple to yellow (Huliselan *et al.*, 2015). Antioxidant activity shows a bioactive substance's ability to inhibit oxidation reactions, which is expressed as a percentage of inhibition (Dewanto *et al.*, 2019). In this study, the measurement of the percentage of DPPH radical scavenging from *S. gibberosa* extracts and vitamin E was used as a control comparison, as could be seen in Figure 5.

The *S. gibberosa* extracts was evaluated for the effect of DPPH radical scavenging for IC₅₀ determination (Table 3). The *S. gibberosa* extracts showed antioxidant potential because it can donate a hydrogen atom/electron to react with DPPH radicals. According to Blois (1958), there are four categories of antioxidant activity: very strong (IC₅₀ < 50 µg/mL), strong (IC₅₀ between 50-100 µg/mL), moderate (IC₅₀ between 100-150 µg/mL), and weak (IC₅₀ between 150-200 µg/mL). Based on the IC₅₀, *Sinularia gibberosa* extracts was classified as strong

antioxidants. Compounds with carboxyl and hydroxyl groups are thought to play a significant role as antioxidants (Chen *et al.*, 2020; Godlewska-żytkiewicz *et al.*, 2020). Compounds with carboxyl and hydroxyl groups can act as proton donors and electron acceptors to scavenge and stabilize free radical molecules (Alavi Rafiee *et al.*, 2018). The results showed that increasing the concentration of *S. gibberosa* extracts increased the percentage of DPPH radical scavenging (Figure 5).

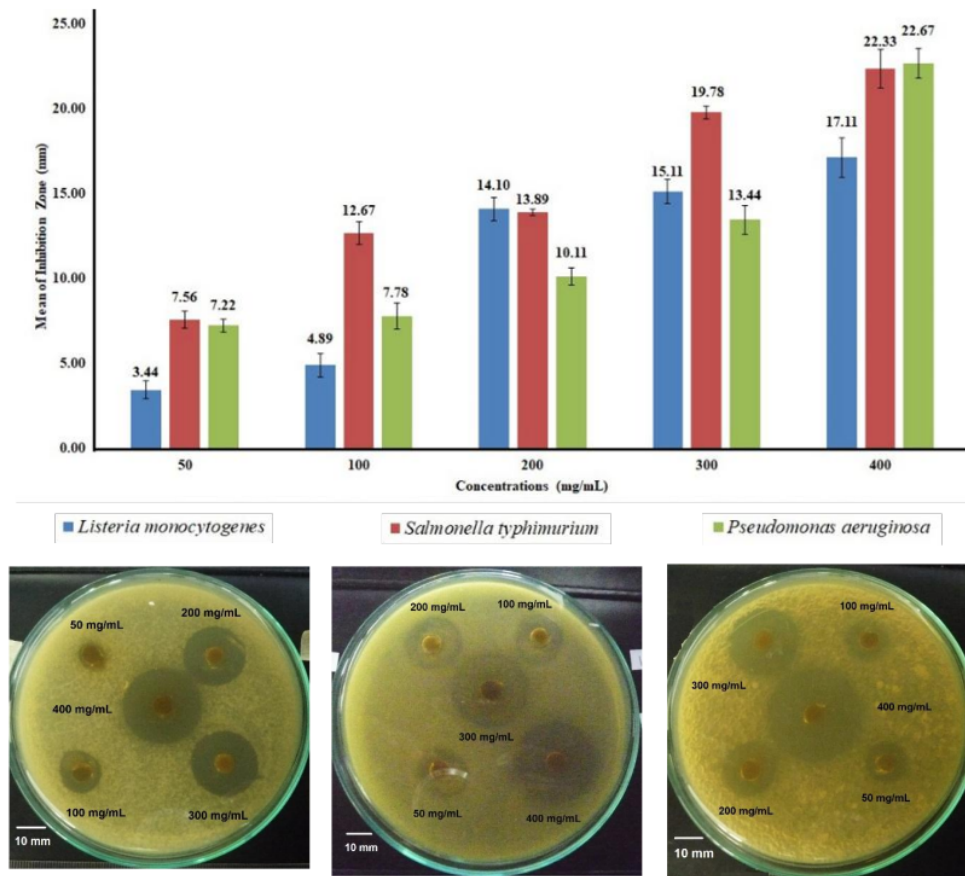


Figure 3. Inhibition Zone of *Sinularia gibberosa* Extracts

Table 2. MIC and MBC of *Sinularia gibberosa* Extracts Against The Tested Bacteria

Bacteria	Regression Equations	R ²	MIC (mg/mL)	MBC (mg/mL)
<i>Listeria monocytogenes</i>	y = 143.87x - 582.91	0.92	1.01	4.05
<i>Salmonella typhimurium</i>	y = 199.33x - 756.93	0.87	0.95	3.80
<i>Pseudomonas aeruginosa</i>	y = 172.89x - 700.22	0.57	1.01	4.05

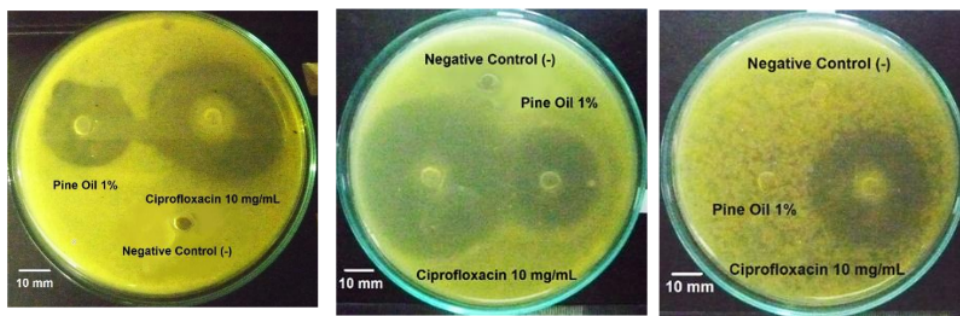
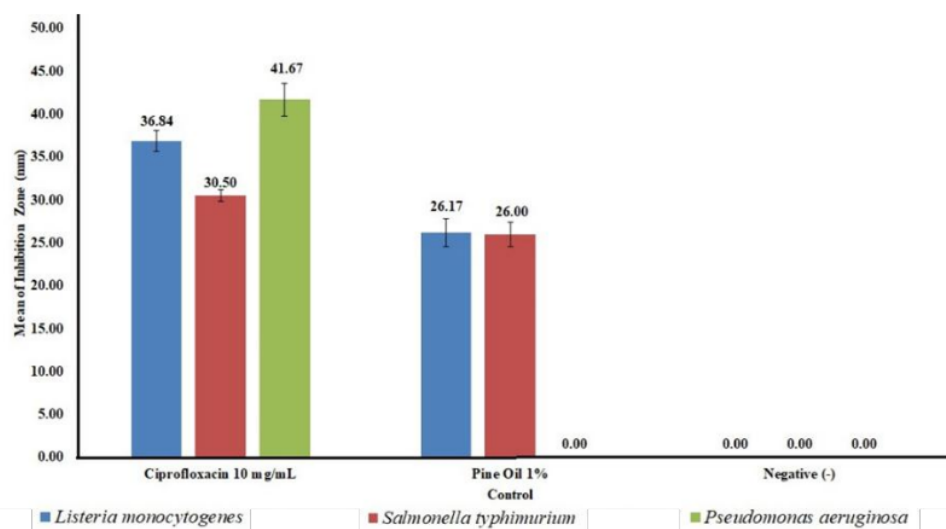


Figure 4. Inhibition zone diameter of positive and negative controls to test bacteria

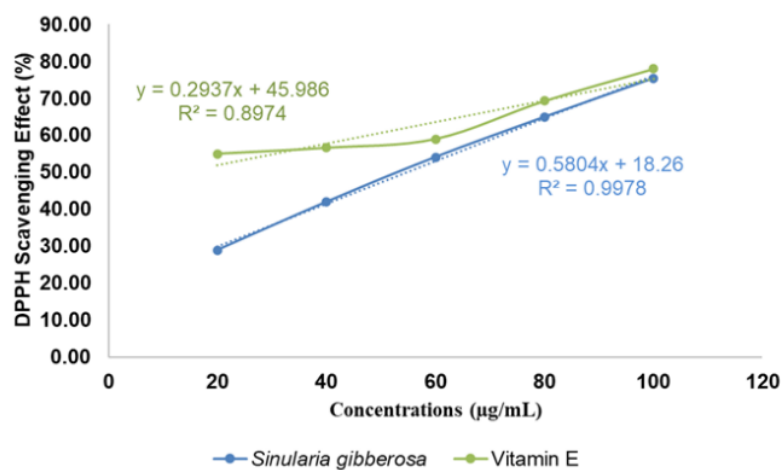


Figure 5. DPPH Scavenging Effect from *Sinularia Gibberosa* Extracts Compared to Vitamin E

Table 3. IC₅₀ of *Sinularia gibberosa* extracts compared with Vitamin E.

Samples	IC ₅₀ (μg/mL)
<i>Sinularia gibberosa</i>	54.69 ± 0.34
Vitamin E	15.87 ± 4.47

Vitamin E, as control, has one hydroxyl group. Vitamin E is a natural antioxidant compound often used as a comparison compound in antioxidant activity assays. This assay showed that vitamin E is a very strong antioxidant compound. From literature studies, the IC₅₀ of vitamin E ranges from 8-23 μg/mL, depends on DPPH concentrations (Cheng *et al.*, 2013; Melannisa *et al.*, 2011; Da'i and Triharman, 2010; Yassa *et al.*, 2009; Rohman *et al.*, 2007).

The results of total phenol measurement from *S. gibberosa* extracts obtained 5423.76 ± 14.00 mg GAE/25 mg dry extracts. Previous studies have also reported the total phenol content of *S. polydactyla*, *S. variabilis*, and *S. compresa* in the range of 47.60 - 63.32 mg/L (Yegdaneh *et al.*, 2020). The total phenol content is an indicator to determine the amount of phenolic content in the sample. The phenolic compounds contained in the sample have redox properties, allowing them to act as antioxidants (Johari and Khong, 2019). Phenolic compounds have hydroxyl groups and are responsible for facilitating free radical scavenging (Aryal *et al.*, 2019).

Previous research has shown that soft coral extracts from the genus *Sinularia* also showed potential as antioxidants. Twenty-four diterpenoid derivatives isolated from *S. maxima* showed moderate to a strong peroxy radical scavenging capacity (Thao *et al.*, 2015). *Sinularia* sp., which was collected from Pongok Island, Indonesia, detects flavonoid derivative components that can act as antioxidants (Apri *et al.*, 2013). Two sesquiterpene compounds were isolated from *Sinularia* sp. collected from the Sanya bay, China (Zhang *et al.*, 2006).

Bioactive substances from soft corals are thought to interact with each other to provide antibacterial and antioxidant properties. Bioactive compounds from organisms (including marine organisms) can work synergistically between one compound and another (Merzenich *et al.*, 2010). Bioactive compounds can work through multi-compound and multi-target synergistic modes (Long *et al.*, 2015). The results of this study proved that *Sinularia gibberosa* soft corals from Palu Bay, Central Sulawesi, Indonesia produced various compounds with antibacterial and antioxidant properties.

CONCLUSION

Based on the results, soft coral *Sinularia gibberosa* from Palu Bay, Central Sulawesi, showed moderate to strong antibacterial activity against the growth of *L. monocytogenes*, *S. typhimurium*, and *P. aeruginosa*. The extracts of *S. gibberosa* are more effective at inhibiting Gram-negative than Gram-positive bacteria. Apart from that, *S. gibberosa* extracts also showed strong antioxidant potential with an IC₅₀ of 54.69 ± 0.34 μg/mL. The chemical profiles of *S. gibberosa* extracts using LC-HRMS obtained 29 compounds with quality above 85% and was dominated by compounds of fatty acid derivatives. This study indicated that soft corals from Palu Bay, Central Sulawesi, Indonesia, could be potential organisms in

discovering and developing antibacterial and antioxidant agents.

ACKNOWLEDGEMENT

All authors would like to thank the Directorate of Research and Community Service, Deputy for Strengthening Research and Development, Ministry of Research and Technology/National Research and Innovation Agency, Republic of Indonesia for funding this research through a research grant for beginner lecturer research schemes in 2020 (No. 189/SP2H/AMD/LT/DRPM/2020). The authors also express their gratitude to the Director of the Institute of Fisheries and Marine (Sekolah Tinggi Perikanan dan Kelautan – STPL Palu) for providing facilities and support to complete this research. All authors also thanks to Dr. Firman Farid Muhsoni. Not to forget that all authors also grateful to Siti Khalimatu Sa'diah, S.Pi., Fatma, S.Pi., and Moh. Ahdiat, S.Pi. which assists assaying at the laboratory.

REFERENCES

- Affi, R., Abdel-Nabi, I. M., & El-Shaikh, K. (2016). Antibacterial activity from soft corals of the Red Sea, Saudi Arabia. *Journal of Taibah University for Science*, 10(6), 887–895. <https://doi.org/10.1016/j.jtusci.2016.03.006>
- Ahmed, A. F., Hsieh, Y. T., Wen, Z. H., Wu, Y. C., & Sheu, J. H. (2006). Polyoxygenated sterols from the formosan soft coral *Sinularia gibberosa*. *Journal of Natural Products*, 69(9), 1275–1279. <https://doi.org/10.1021/np0601509>
- Ahmed, A. F., Wen, Z.-H., Su, J.-H., Hsieh, Y.-T., Wu, Y.-C., Hu, W.-P., & Sheu, J.-H. (2008). Oxygenated cembranoids from a Formosan soft coral *Sinularia gibberosa*. *Journal of Natural Products*, 71(2), 179–185. <https://doi.org/10.1021/np070356p>
- Alavi Rafiee, S., Farhoosh, R., & Sharif, A. (2018). Antioxidant Activity of Gallic Acid as Affected by an Extra Carboxyl Group than Pyrogallol in Various Oxidative Environments. *European Journal of Lipid Science and Technology*, 120(11), 1–8. <https://doi.org/10.1002/ejlt.201800319>
- Alhaddad, Z. A., Wahyudi, D., & Tanod, W. A. (2019). Antibacterial Bioactivity of Mangrove Leaf Extracts *Avicennia* sp. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 12(1), 12–22. <https://doi.org/10.21107/jk.v12i1.4752>
- Alves, E., Dias, M., Lopes, D., Almeida, A., Domingues, M. D. R., & Rey, F. (2020). Antimicrobial lipids from plants and marine organisms: An overview of the current state-of-the-art and future prospects. *Antibiotics*, 9(8), 1–88. <https://doi.org/10.3390/antibiotics9080441>
- Apri, R., Zamani, N. P., & Effendi, H. (2013). Exploration of Soft Coral as Antioxidant at Pongok Island, South Bangka. *Journal of Fisheries and Marine Technology*, 4(2), 211–217. <https://doi.org/10.24319/jtpk.4.211-217>
- Aryal, S., Baniya, M. K., Danekhu, K., Kunwar, P., Gurung, R., & Koirala, N. (2019). Total Phenolic content, Flavonoid content and antioxidant potential of wild vegetables from western Nepal. *Plants*, 8(4), 96–108. <https://doi.org/10.3390/plants8040096>

- Balouiri, M., Sadiki, M., & Ibsouda, S. K. (2016). Methods for in vitro evaluating antimicrobial activity: A review. *Journal of Pharmaceutical Analysis*, 6, 71–79. <https://doi.org/10.1016/j.jppha.2015.11.005>
- Bishara, A., Rudi, A., Benayahu, Y., & Kashman, Y. (2007). Three biscembranoids and their monomeric counterpart cembranoid, a biogenetic diels-alder precursor, from the soft coral *Sarcophyton elegans*. *Journal of Natural Products*, 70(12), 1951–1954. <https://doi.org/10.1021/np070129n>
- Blainski, A., Lopes, G. C., & De Mello, J. C. P. (2013). Application and analysis of the folin ciocalteu method for the determination of the total phenolic content from *Limonium brasiliense* L. *Molecules*, 18(6), 6852–6865. <https://doi.org/10.3390/molecules18066852>
- Blois, M. (1958). Antioxidant determinations by the use of a stable free radical. *Nature*, 181(4617), 1199–1200. <https://doi.org/10.1038/1811199a0>
- Bloomfield, S. F. (1991). Methods for assessing antimicrobial activity in mechanism of action of chemical biocides thesis study and explanation. In S. Denyer & B. W. Hogo (Ed). Blackwell Scientific Publication Ltd. 22 p.
- Blunt, J. W., Copp, B. R., Keyzers, R. A., Munro, M. H. G., & Prinsep, M. R. (2013). Marine natural products. *Natural Product Reports*, 30(2), 237–323. <https://doi.org/10.1039/c2np20112g>
- Byju, K., Anuradha, V., Rosmine, E., Sankar, H. S. H., Gopinath, A., Peter, K. J. P., Kumar, T. R. G., Vasundhara, G., Kumar, N. C., & Nair, S. M. (2015). DPPH scavenging property of active principles from soft coral *Sarcophyton flexuosum* Tixier-Durivault. *Pharmaceutical Chemistry Journal*, 49(3), 178–182. <https://doi.org/10.1007/s11094-015-1249-1>
- Chen, J., Yang, J., Ma, L., Li, J., Shahzad, N., & Kim, C. K. (2020). Structure-antioxidant activity relationship of methoxy, phenolic hydroxyl, and carboxylic acid groups of phenolic acids. *Scientific Reports*, 10(1), 1–9. <https://doi.org/10.1038/s41598-020-59451-z>
- Chen, S. P., Ahmed, A. F., Dai, C. F., Lu, C. K., Hu, W. P., Wang, J. J., & Sheu, J. H. (2006). Sinugibberosides A–E, new terpenoids with cyclic peroxyhemiketal from the soft coral *Sinularia gibberosa*. *Tetrahedron*, 62(29), 6802–6807. <https://doi.org/10.1016/j.tet.2006.04.088>
- Cheng, K. C., Wu, J. Y., Lin, J. T., & Liu, W. H. (2013). Enhancements of isoflavone aglycones, total phenolic content, and antioxidant activity of black soybean by solid-state fermentation with *Rhizopus* spp. *European Food Research and Technology*, 236(6), 1107–1113. <https://doi.org/10.1007/s00217-013-1936-7>
- Da'i, M., & Triharman, F. (2010). DPPH (1,1-diphenyl-2-picrilhidrazil) radical scavenging activity of alfa mangostin that isolated from mangosteen rind (*Garcinia mangostana* L.). *Pharmakon*, 11(2), 47–50.
- Dewanto, D. K., Hermawan, R., Muliadin, Riyadi, P. H., Aisiah, S., & Tanod, W. A. (2021). GC-MS profile of *Rhizophora apiculata* leaf extract from the coast of Tomini bay, Central Sulawesi with antibacterial and antioxidant activity. *Jurnal Kelautan: Indonesian Journal of Marine Science and Technology*, 14(1), 30–42. <https://doi.org/10.21107/jk.v14i1.8904>
- Dewanto, D. K., Finarti, F., Hermawan, R., Ndobe, S., Riyadi, P. H., & Tanod, W. A. (2019). Aktivitas antioksidan ekstrak karang lunak asal Teluk Palu, Sulawesi Tengah, Indonesia. *Jurnal Pascapanen Dan Bioteknologi Kelautan Dan Perikanan*, 14(2), 163–178. <https://doi.org/10.15578/jpbkp.v14i2.583>
- Do Nascimento, P. G. G., Lemos, T. L. G., Bizerra, A. M. C., Arriaga, A. M. C., Ferreira, D. A., Santiago, G. M. P., Braz-Filho, R., & Costa, J. G. M. (2014). Antibacterial and antioxidant activities of ursolic acid and derivatives. *Molecules*, 19(1), 1317–1327. <https://doi.org/10.3390/molecules19011317>
- Dobretsov, S., Al-Wahaibi, A. S. M., Lai, D., Al-Sabahi, J., Claereboudt, M., Proksch, P., & Soussi, B. (2015). Inhibition of bacterial fouling by soft coral natural products. *International Biodeterioration & Biodegradation*, 98, 53–58. <https://doi.org/10.1016/j.ibiod.2014.10.019>
- Ermolenko, E. V., Imbs, A. B., Glorizova, T. A., Poroikov, V. V., Sikorskaya, T. V., & Dembitsky, V. M. (2020). Chemical Diversity of Soft Coral Steroids and Their Pharmacological Activities. *Marine Drugs*, 18(12), 613–647. <https://doi.org/10.3390/md18120613>
- Fabricus, K., & Alderslade, P. (2001). Soft corals and sea fans, a comprehensive guide to the tropical shallow-water genera of the Central-West Pacific, The Indian Ocean and the Red Sea. Queensland: Australian Institute of Marine Science. 264 p.
- Fekih, N., Allali, H., Merghache, S., Chaïb, F., Merghache, D., El Amine, M., Djabou, N., Muselli, A., Tabti, B., & Costa, J. (2014). Chemical composition and antibacterial activity of *Pinus halepensis* Miller growing in West Northern of Algeria. *Asian Pacific Journal of Tropical Disease*, 4(2), 97–103. [https://doi.org/10.1016/S2222-1808\(14\)60323-6](https://doi.org/10.1016/S2222-1808(14)60323-6)
- Godlewska-żyłkiewicz, B., Świsłocka, R., Kalinowska, M., Golonko, A., Świdorski, G., Arciszewska, Ż., Nalewajko-Sieliwoniuk, E., Naumowicz, M., & Lewandowski, W. (2020). Biologically active compounds of plants: Structure-related antioxidant, microbiological and cytotoxic activity of selected carboxylic acids. *Materials*, 13(19), 1–37. <https://doi.org/10.3390/ma13194454>
- Hsiao, T.H., Sung, C.S., Lan, Y.H., Wang, Y.C., Lu, M.C., Wen, Z.H., Wu, Y.C., & Sung, P.J. (2015). New Anti-Inflammatory cembranes from the cultured soft coral *Nephthea columnaris*. *Marine Drugs*, 13(6), 3443–3453. <https://doi.org/10.3390/md13063443>
- Huliselan, Y. M., Runtuwene, M. R. J., & Wewengkang, D. S. (2015). Antioxidant activity of ethanol, ethyl acetate and n-hexane extract from seswau leaves (*Clerodendron squamatum* Vahl.). *Pharmakon*, 4(3), 155–163.
- Imbs, A. B., Luu, H. V., & Pham, L. Q. (2007). Lipids of soft coral *Sinularia* species. *Chemistry of Natural Compounds*, 43(5), 610–611. <https://doi.org/10.1007/s10600-007-0204-0>
- Ishii, T., Matsuura, H., Zhan, Z. Q., & Vairappan, C. S. (2009). A new norsesquiterpenoid from a Bornean soft coral genus *Nephthea*. *Molecules*, 14(11), 4591–4596. <https://doi.org/10.3390/molecules14114591>
- Jawetz, E., Melnick, J., & Adelberg, E. (2005). Mikrobiologi

- Kedokteran. Penerbit Buku Kedokteran EGC. Jakarta 862 p.
- Jin, C., Gibani, M. M., Pennington, S. H., Liu, X., Ardrey, A., Aljayyousi, G., Moore, M., Angus, B., Parry, C. M., Biagini, G. A., Feasey, N. A., & Pollard, A. J. (2019). Treatment responses to azithromycin and ciprofloxacin in uncomplicated *Salmonella typhi* infection: a comparison of clinical and microbiological data from a controlled human infection model. *PLoS Neglected Tropical Diseases*, 13(12), e0007955. <https://doi.org/10.1371/JOURNAL.PNTD.0007955>
- Kabara, J. J., Swieczkowski, D. M., Conley, A. J., & Truant, J. P. (1972). Fatty acids and derivatives as antimicrobial agents. *Antimicrobial Agents and Chemotherapy*, 2(1), 23–28.
- Karthikeyan, S. C., Velmurugan, S., Donio, M. B. S., Michaelbabu, M., & Citarasu, T. (2014). Studies on the antimicrobial potential and structural characterization of fatty acids extracted from Sydney rock oyster *Saccostrea glomerata*. *Annals of Clinical Microbiology and Antimicrobials*, 13(1), 1–11. <https://doi.org/10.1186/s12941-014-0057-x>
- Johari, M. A., & Khong, H. Y. (2019). Total Phenolic Content and Antioxidant and Antibacterial Activities of *Pereskia bleo*. *Advances in Pharmacological Sciences*, 2019, 1–4. <https://doi.org/10.1155/2019/7428593>
- Lamuela-Raventós, R. M. (2017). Folin-Ciocalteu method for the measurement of total phenolic content and antioxidant capacity. In R. Apak, E. Capanoglu, & F. Shahidi (Ed.), *Measurement of Antioxidant Activity and Capacity: Recent Trends and Applications*. John Wiley & Sons Ltd. New Jersey. pp. 107–115 <https://doi.org/10.1002/9781119135388.ch6>
- Leal, M. C., Puga, J., Serodio, J., Gomes, N. C. M., & Calado, R. (2012). Trends in the discovery of new marine natural products from invertebrates over the last two decades - where and what are we bioprospecting? *PLoS ONE*, 7(1), e30580. <https://doi.org/10.1371/journal.pone.0030580>
- Li, G., Zhang, Y., Deng, Z., Van Ofwegen, L., Proksch, P., & Lin, W. (2005). Cytotoxic cembranoid diterpenes from a soft coral *Sinularia gibberosa*. *Journal of Natural Products*, 68, 649–652. <https://doi.org/10.1021/np040197z>
- Liang, L. F., Wang, X. J., Zhang, H. Y., Liu, H. L., Li, J., Lan, L. F., Zhang, W., & Guo, Y. W. (2013). Bioactive polyhydroxylated steroids from the Hainan soft coral *Sinularia depressa* Tixier-Durivault. *Bioorganic & Medicinal Chemistry Letters*, 23(5), 1334–1337. <https://doi.org/10.1016/j.bmcl.2012.12.087>
- Lin, H. F., Su, H. J., Lee, N. L., & Su, J. H. (2013). Cembranoids from the cultured soft coral *Sinularia gibberosa*. *Natural Product Communications*, 8(10), 1363–1364. <https://doi.org/10.1177/1934578x1300801004>
- Liu, L., Zheng, Y.Y., Shao, C.L., & Wang, C.Y. (2019). Metabolites from marine invertebrates and their symbiotic microorganisms: molecular diversity discovery, mining, and application. *Marine Life Science & Technology*, 1(1), 60–94. <https://doi.org/10.1007/s42995-019-00021-2>
- Liu, R. M., Li, Y. B., Liang, X. F., Liu, H. Z., Xiao, J. H., & Zhong, J. J. (2015). Structurally related ganoderic acids induce apoptosis in human cervical cancer HeLa cells: Involvement of oxidative stress and antioxidant protective system. *Chemico-Biological Interactions*, 240, 134–144. <https://doi.org/10.1016/j.cbi.2015.08.005>
- Long, F., Yang, H., Xu, Y., Hao, H., & Li, P. (2015). A strategy for the identification of combinatorial bioactive compounds contributing to the holistic effect of herbal medicines. *Nature Publishing Group*, January, 1–11. <https://doi.org/10.1038/srep12361>
- Maggi, N., Furesz, S., & Sensi, P. (1968). The influence of the carboxyl group upon the antibacterial activity of rifamycins. *Journal of Medicinal Chemistry*, 11(2), 368–369. <https://doi.org/10.1021/jm00308a042>
- Marfuati, N., Rakhmawatie, M. D., & Akmalia, N. R. (2017). The effectivity of ciprofloxacin on the growth of uropatogenic *Escherichia coli* in vitro. *Jurnal Kedokteran Muhammadiyah*, 2, 1–7.
- Melannisa, R., Da'i, M., & Rahmi, R. T. (2011). Radical scavenging activity assay and determination of total phenolic content of ethanol extract three curcuma genus rhizomes and figerroot rhizome (*Boesenbergia pandurata*). *Pharmakon*, 12(1), 40–43.
- Merzenich, G. U., Panek, D., Zeitler, H., Vetter, H., & Wagner, H. (2010). Drug development from natural products: Exploiting synergistic effects. *Indian Journal of Experimental Biology*, 48(March), 208–219.
- Molyneux, P. (2004). The use of the stable free radical diphenylpicryl- hydrazyl (DPPH) for estimating antioxidant activity. *Songklanakarin Journal of Science and Technology*, 26, 211–219. <https://doi.org/10.1287/isre.6.2.144>
- Paudel, B., Bhattarai, H. D., Kim, I. C., Lee, H., Sofronov, R., Ivanova, L., Poryadina, L., & Yim, J. H. (2014). Estimation of antioxidant, antimicrobial activity and brine shrimp toxicity of plants collected from Oymyakon region of the republic of Sakha (Yakutia), Russia. *Biological Research*, 47(1), 1–6. <https://doi.org/10.1186/0717-6287-47-10>
- Putra, M. Y., Murniasih, T., Swasono, R. T., Wibowo, J. T., Saputri, A. N. C., Widhiana, M. R., & Arlyza, I. S. (2016a). Secondary metabolites and their biological activities in Indonesian soft coral of the genus *Lobophytum*. *Asian Pacific Journal of Tropical Biomedicine*, 6(11), 909–913. <https://doi.org/10.1016/j.apjtb.2016.08.011>
- Putra, M. Y., Wibowo, J. T., Murniasih, T., & Rasyid, A. (2016b). Evaluation of antibacterial activity from Indonesian marine soft coral *Sinularia* sp. *American Institute of Physics Conference Proceedings*, 1744, 020039. <https://doi.org/10.1063/1.4953513>
- Radić, N., & Strukelj, B. (2012). Endophytic fungi: the treasure chest of antibacterial substances. *Phytomedicine : International Journal of Phytotherapy and Phytopharmacology*, 19(14), 1270–1284. <https://doi.org/10.1016/j.phymed.2012.09.007>
- Rajaram, S., Ramesh, D., Ramulu, U., Anjum, M., Kumar, P., Murthy, U. S. N., Hussain, M. A., Sastry, G. N., & Venkateswarlu, Y. (2014). Chemical examination of the soft coral *Sinularia kavarattiensis* and evaluation of anti-microbial activity. *Indian Journal of Chemistry - Section B Organic and Medicinal Chemistry*, 53(8),

- 1086–1090.
- Rice, L. B. (2008). Federal funding for the study of antimicrobial resistance in nosocomial pathogens: no ESKAPE. *The Journal of Infectious Diseases*, 197(8), 1079–1081. <https://doi.org/10.1086/533452>
- Riyadi, P. H., Wahyudi, D., & Tanod, W. A. (2019). Effects of dichloromethane *Sarcophyton* spp. extract on the lipopolysaccharide-induced expression of nuclear factor-kappa B and inducible nitric oxide synthase in mice. *Veterinary World*, 12(12), 1897–1902.
- Rohman, A., Riyanto, S., & Hidayat, N. K. (2007). Antioxidant activity, total phenolics and total flavonoid contents of mengkudu (*Morinda citrifolia* L) leaves. *Agritech*, 27(4), 147–151.
- Romansyah, Y. (2011). The content of bioactive antioxidant compound soft corals *Sarcophyton* sp. natural and transplantation in the coastals of Pramuka Island, Seribu Archipelago. Thesis. IPB University. Bogor. 45 p.
- Salanggon, A. M., Aswani, S., Hasanuddin, A., Hermawan, R., Riyadi, P. H., Dewanto, D. K., & Tanod, W. A. (2020). Anti-bacterial activity of the softcoral *Sinularia* sp. using broth-dilution method. *Jurnal Kelautan Nasional*, 15(3), 153–164. <https://doi.org/10.15578/jkn.v15i3.9057>
- Sun, P., Meng, L. Y., Tang, H., Liu, B. S., Li, L., Yi, Y., & Zhang, W. (2012). Sinularosides A and B, bioactive 9,11-secosteroidal glycosides from the South China Sea soft coral *Sinularia humilis* Ofwegen. *Journal of Natural Products*, 75, 1656–1659. <https://doi.org/10.1021/np300475d>
- Supriharyono. (2000). Pelestarian dan Pengelolaan Sumberdaya Alam di Wilayah Pesisir Tropis. PT. Gramedia Pustaka Utama. Jakarta. 246 p.
- Tanod, W. A., Aristawati, A. T., Putra, M. Y., & Muliadin. (2018a). Soft Coral (*Sinularia* sp.) extracts with antibacterial activity. *Omni-Akuatika*, 14(1), 108–117. <https://dx.doi.org/10.20884/1.oa.2018.14.1.375>
- Tanod, W. A., Aristawati, A. T., Nurhani, & Mappiratu. (2018b). Antifeedants activity of soft coral extract *Sinularia* sp. with variation of ethanol concentration. In W. A. Nugraha, A. Romadhon, & Insafitri (Ed), Proceeding of National Seminar in Fisheries and Marine III, Vol. 1. University of Trunojoyo, Madura.
- Tanod, W. A., Yanuhar, U., Maftuch, Putra, M. Y., & Risjani, Y. (2019a). Screening of NO inhibitor release activity from soft coral extracts origin Palu Bay, Central Sulawesi, Indonesia. *Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistry*, 18(2), 126–141 <https://doi.org/10.2174/1871523018666190222115034>
- Tanod, W. A., Dewanto, D. K., Ndobe, S., Riyadi, P. H., & Putra, M. Y. (2019b). Screening of antibacterial and antioxidant activity of soft corals *Sinularia* sp. and *Sarcophyton* sp. from Palu Bay Central Sulawesi. *Squalen: Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 14(2), 73–83. <https://dx.doi.org/10.15578/squalen.v14i2.394>
- Tanod, W. A., Yanuhar, U., Maftuch, Wahyudi, D., & Risjani, Y. (2019c). DPPH scavenging property of bioactives from soft corals origin palu bay, Central Sulawesi, Indonesia. IOP Conf Series: *Earth and Environmental Science*, 236, 012121, <https://doi.org/10.1088/1755-1315/236/1/012121>
- Tanod, W. A., Mangindaan, R. E., & Kapojos, M. (2015). Antimitotic activity from soft coral genus *Sinularia* extracts. *Omni-Akuatika*, 11(2), 41–49. <https://dx.doi.org/10.20884/1.oa.2015.11.2.38>
- Tapilatu, Y. H. (2015). Status of drug discovery research based on marine organisms from Eastern Indonesia. *Procedia Chemistry*, 14, 484–492. <https://doi.org/10.1016/j.proche.2015.03.065>
- Thao, N. P., Luyen, B. T. T., Lee, S. H., Jang, H. D., Kiem, P. V., Minh, C. V., & Kim, Y. H. (2015). Antiosteoporotic and antioxidant activities of diterpenoids from the Vietnamese soft corals *Sinularia maxima* and *Lobophytum crassum*. *Medicinal Chemistry Research*, 24(9). <https://doi.org/10.1007/s00044-015-1395-8>
- Tillah, M., Batubara, I., & Sari, R. K. (2017). Antimicrobial and Antioxidant Activities of Resins and Essential Oil From Pine (*Pinus merkusii*, *Pinus ocarpa*, *Pinus insularis*) and Agathis (*Agathis loranthifolia*). *Biosaintifika: Journal of Biology & Biology Education*, 9(1), 134–139. <https://doi.org/10.15294/biosaintifika.v9i1.8371>
- Wright, G. D., & Sutherland, A. D. (2007). New strategies for combating multidrug-resistant bacteria. *Trends in Molecular Medicine*, 13(6), 260–267. <https://doi.org/10.1016/j.molmed.2007.04.004>
- Yassa, N., Masoomi, F., Rankouhi, S. R., & Hadjiakhoondi, A. (2009). Chemical composition and antioxidant activity of the extract and essential oil of *Rosa damascena* from Iran, population of Guilan. *DARU Journal of Pharmaceutical Sciences*, 17(3), 175–180.
- Yegdaneh, A., Mohammadi, E., Mehdinezhad, N., Shabani, L., & Pour, P. M. (2020). Evaluation of cytotoxic and antioxidant activity and total phenolic content of some soft corals from the persian gulf. *Iranian Journal of Pharmaceutical Sciences*, 16(3), 1–10.
- Zhang, G. W., Ma, X. Q., Su, J. Y., Zhang, K., Kurihara, H., Yao, X. S., & Zeng, L. M. (2006). Two new bioactive sesquiterpenes from the soft coral *Sinularia* sp. *Natural Product Research*, 20(7), 659–664. <https://doi.org/R5R2Q61261881U47> [pii]v10.1080/14786410500183233
- Zi, Y., Zhu, M., Li, X., Xu, Y., Wei, H., Li, D., & Mu, C. (2018). Effects of carboxyl and aldehyde groups on the antibacterial activity of oxidized amylose. *Carbohydrate Polymers*, 192, 118–125. <https://doi.org/10.1016/j.carbpol.2018.03.06>

SOFT CORAL *Sinularia gibberosa* EXTRACTS ORIGIN PALU BAY, CENTRAL SULAWESI WITH ANTIBACTERIAL AND ANTIOXIDANT ACTIVITY

ORIGINALITY REPORT

18%

SIMILARITY INDEX

%

INTERNET SOURCES

18%

PUBLICATIONS

%

STUDENT PAPERS

PRIMARY SOURCES

1

W A Tanod, U Yanuhar, Maftuch, D Wahyudi, Y Risjani. "DPPH scavenging property of bioactives from soft corals origin palu bay, Central Sulawesi, Indonesia", IOP Conference Series: Earth and Environmental Science, 2019

Publication

2%

2

A N Damayanti, P H Riyadi, E N Dewi. "Characteristic and boactive potential of brewed *Sargassum* sp. with the additional bay leaf (*Syzygium polyanthum*)", IOP Conference Series: Earth and Environmental Science, 2021

Publication

2%

3

A Junaidi, C Kartiko. "Design of Pond Water Quality Monitoring System Based on Internet of Things and Pond Fish Market in Real-Time to Support the Industrial Revolution 4.0", IOP Conference Series: Materials Science and Engineering, 2020

Publication

1%

4

Wendy Alexander Tanod, Uun Yanuhar, Maftuch, Masteria Yunovilsa Putra, Yenny Risjani. "Screening of NO Inhibitor Release Activity from Soft Coral Extracts Origin Palu Bay, Central Sulawesi, Indonesia", Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistry, 2019

Publication

1 %

5

Khadijah, Nunuk Hariani Soekamto, Siti Maisuri Tadjuddin Chalid, Nur Fatin Rafidah. "Total Phenol Content and Activities of Antioxidant Extracts Methanol Limes By Uv-Vis Spectrophotometry ", E3S Web of Conferences, 2021

Publication

1 %

6

Putut Har Riyadi, Mochammad Fitri Atho'illah, Wendy Alexander Tanod, Irma Sarita Rahmawati. "Tilapia viscera hydrolysate extract alleviates oxidative stress and renal damage in deoxycorticosterone acetate-salt-induced hypertension rats", Veterinary World, 2020

Publication

1 %

7

I Nyoman Radiarta, Adang Saputra, Ofri Johan. "Pemetaan Kelayakan Lahan untuk Pengembangan Usaha Budidaya Laut dengan Aplikasi Inderaja dan Sistem Informasi Geografis di Perairan Lemito, Provinsi

<1 %

Gorontalo.", Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan, 2007

Publication

8

Valentino Bervia Lunardi, Felycia Edi Soetaredjo, Kuncoro Foe, Jindrayani Nyoo Putro et al. "Pesticide elimination through adsorption by metal-organic framework and their modified forms", Environmental Nanotechnology, Monitoring & Management, 2022

Publication

<1 %

9

"Encyclopedia of Marine Biotechnology", Wiley, 2020

Publication

<1 %

10

Didit Kustantio Dewanto, Finarti Finarti, Roni Hermawan, Samliok Ndobe, Putut Har Riyadi, Wendy Alexander Tanod. "Aktivitas Antioksidan Ekstrak Karang Lunak Asal Teluk Palu, Sulawesi Tengah, Indonesia", Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan, 2019

Publication

<1 %

11

Adi Parwata, Putra Manuaba, Sutirta Yasa. "The Potency of Flavonoid Compounds in water Extract Gyrinops Versteegii Leaves as Natural Antioxidants Sources", Biomedical and Pharmacology Journal, 2018

Publication

<1 %

12 Jovana Petrović, Magdalini Papandreou, Jasmina Glamočlija, Ana Ćirić et al. "Different extraction methodologies and their influence on the bioactivity of the wild edible mushroom *Laetiporus sulphureus* (Bull.) Murrill", *Food Funct.*, 2014

Publication

<1 %

13 *Biotechnology for Medicinal Plants*, 2013.

Publication

<1 %

14 M T Sibero, D S Zilda, D Haryanti, Y Igarashi. "Astrogorgia sp. from Saparua, Maluku: Phytochemical Content, Antimicrobial, Antioxidant, and Cytotoxicity Properties", *IOP Conference Series: Earth and Environmental Science*, 2021

Publication

<1 %

15 Z Imran, S W Sugiarto, A N Muhammad. "Coastal vulnerability index aftermath tsunami in Palu Bay, Indonesia", *IOP Conference Series: Earth and Environmental Science*, 2020

Publication

<1 %

16 Chandra Bahadur Thapa, Mukti Ram Paudel, Hari Data Bhattarai, Krishna Kumar Pant et al. "Bioactive secondary metabolites in *Paris polyphylla* Sm. and their biological activities: A review", *Heliyon*, 2022

Publication

<1 %

17

Kustiariyah Tarman, Dwi Safitri, Iriani Setyaningsih. "Endophytic Fungi Isolated from *Rhizophora mucronata* and Their Antibacterial Activity", *Squalen Bulletin of Marine and Fisheries Postharvest and Biotechnology*, 2013

Publication

<1 %

18

Talyta Mayara Silva Torres, Jose Antonio Mendiola, Gerardo Álvarez-Rivera, Simone Mazzutti et al. "Protein valorization from ora-pro-nobis leaves by compressed fluids biorefinery extractions", *Innovative Food Science & Emerging Technologies*, 2022

Publication

<1 %

19

Zhen - Xing Wang, Qing - Qing Lin, Zong - Cai Tu, Lu Zhang. " The influence of in vitro gastrointestinal digestion on the leaf extract: Changes in the active compounds and bioactivities ", *Journal of Food Biochemistry*, 2020

Publication

<1 %

20

Hamid Beyzaei, Somaye Kooshki, Reza Aryan, Mohammad Mehdi Zahedi et al. "MgO Nanoparticle-Catalyzed Synthesis and Broad-Spectrum Antibacterial Activity of Imidazolidine- and Tetrahydropyrimidine-2-Thione Derivatives", *Applied Biochemistry and Biotechnology*, 2017

Publication

<1 %

21

"Medicinal Plants and Fungi: Recent Advances in Research and Development", Springer Science and Business Media LLC, 2017

Publication

<1 %

22

Ezinne C. Achinivu, Amandine L. Flourat, Fanny Brunissen, Florent Allais. "Valorization of waste biomass from oleaginous "oil-bearing" seeds through the biocatalytic production of sinapic acid from mustard bran", Biomass and Bioenergy, 2021

Publication

<1 %

23

Farida, Yunahara, Kurnia Irpan, and Lia Fithriani. "Antibacterial and Antioxidant Activity of Keladi Tikus Leaves Extract (Typhonium Flagelliforme) (Lodd) Blume", Procedia Chemistry, 2014.

Publication

<1 %

24

R. Chris Skinner, Derek C. Warren, Minahal Naveed, Garima Agarwal, Vagner A. Benedito, Janet C. Tou. "Apple pomace improves liver and adipose inflammatory and antioxidant status in young female rats consuming a Western diet", Journal of Functional Foods, 2019

Publication

<1 %

25

Zahra Moradi, Maryam Madadkar Haghjou, Mahmoud Zarei, Louise Colville, Ali Raza. "Synergy of production of value-added

<1 %

bioplastic, astaxanthin and phycobilin co-products and Direct Green 6 textile dye remediation in *Spirulina platensis*", *Chemosphere*, 2021

Publication

26

"Biotechnological Applications of Quorum Sensing Inhibitors", Springer Science and Business Media LLC, 2018

Publication

27

Anders Hakansson. "A folding variant of alpha-lactalbumin with bactericidal activity against *Streptococcus pneumoniae*", *Molecular Microbiology*, 2/2000

Publication

28

Ciliana Flórez-Montes, Óscar Marino Mosquera-Martínez, Andrés Felipe Rojas-González. "Prospective use of fruit byproducts in Colombia according to their antioxidant capacity", *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 2020

Publication

29

Jui-Hsin Su, Yen-Ju Tseng, Hsin-Hui Huang, Atallah F. Ahmed, Chung-Kuang Lu, Yang-Chang Wu, Jyh-Horng Sheu. " 9,11-Secosterols from the Soft Corals and ", *Journal of Natural Products*, 2006

Publication

<1 %

<1 %

<1 %

<1 %

30

Katy Soapi, Klaus-D. Feussner, William G. Aalbersberg. "Antimicrobial and cytotoxic activities of marine plants and invertebrates from the coast of Espirito Santo in Vanuatu", The South Pacific Journal of Natural and Applied Sciences, 2013

Publication

<1 %

31

Lin-Hao Zhang, Li-Li Jin, Fang Liu, Chunmei Jin, Chun-Mei Jin, Zhi-Yu Wei. "Evaluation of ursolic acid derivatives with potential anti-Toxoplasma gondii activity", Experimental Parasitology, 2020

Publication

<1 %

32

Putut Har Riyadi, Didik Wahyudi, Wendy Alexander Tanod. "Effects of dichloromethane Sarcophyton spp. extract on the lipopolysaccharide-induced expression of nuclear factor-kappa B and inducible nitric oxide synthase in mice", Veterinary World, 2019

Publication

<1 %

33

S Aisiah, Olga, W A Tanod, Y Salosso, Bambang, P H Riyadi. "Computational analysis of ethyl acetate extract of Nauclea subdita (Korth.) Steud. leaves as peptidoglycan glycosyltransferase inhibitor in Aeromonas hydrophila", IOP Conference Series: Earth and Environmental Science, 2020

<1 %

34 Said Abbout, Driss CHEBABE, Malak REHIOUI, Hamid ERRAMLI, Najat HAJJAJI. "Chemical Composition and Antioxidant Activity of the Ceratonia Siliqua L. Seeds Oil", Research Square Platform LLC, 2021 $<1\%$

Publication

35 Xia Yan, Jing Liu, Xue Leng, Han Ouyang. "Chemical Diversity and Biological Activity of Secondary Metabolites from Soft Coral Genus Sinularia since 2013", Marine Drugs, 2021 $<1\%$

Publication

36 Ahmed Abdel-Lateff, Walied Alarif, Najla Alburae, Mardi Algandaby. "Alcyonium Octocorals: Potential Source of Diverse Bioactive Terpenoids", Molecules, 2019 $<1\%$

Publication

37 Evolutionary Ethnobiology, 2015. $<1\%$

Publication

38 Haidy N. Kamel, Marc Slattery. " Terpenoids of .: Chemistry and Biomedical Applications ", Pharmaceutical Biology, 2008 $<1\%$

Publication

39 Ibtisam Mohammed Ababutain, Azzah Ibrahim Alghamdi. " In vitro anticandidal activity and gas chromatography-mass $<1\%$

spectrometry (GC-MS) screening of leaf
extracts ", PeerJ, 2021

Publication

40

Liu, B.. "Synthesis and evaluation of anti-tumor activities of N⁴ fatty acyl amino acid derivatives of 1- β -arabinofuranosylcytosine", European Journal of Medicinal Chemistry, 200909

Publication

<1 %

41

Martin M. Gakuubi, Kiraithe N. Micheni, Wycliffe Wanzala. " Antibacterial Activity of Essential Oil from the Fruits of (L) Lam. (Rutaceae) ", Journal of Biologically Active Products from Nature, 2017

Publication

<1 %

42

Muhammad Ashif, IDSAP Peramiarti, Afifah. "ANTIBACTERIAL ACTIVITY OF KECOMBRANG FRUIT SIMPLICIA EKTRACT (Nicolaia speciosa) AGAINST GRAM POSITIVE BACTERIA Staphylococcus aureus FNCC 0047 IN VITRO", IOP Conference Series: Earth and Environmental Science, 2019

Publication

<1 %

43

PH Riyadi, Romadhon, AD Anggo, S Suharto, WA Tanod, A Aryani. "Anti-Inflammatory Potential from Tilapia (Oreochromis niloticus) Viscera Hydrolysate with Bioinformatics Analysis (Prediction of Activity Spectra for

<1 %

Substances – PASS)", IOP Conference Series:
Earth and Environmental Science, 2021

Publication

44

R.M.E. Richards. "Activity of p-aminobenzoic acid compared with other organic acids against selected bacteria", Journal of Applied Microbiology, 3/1995

Publication

<1 %

45

Yannai, . "Name Index", Dictionary of Food Compounds with CD-ROM Second Edition, 2012.

Publication

<1 %

46

Yu Tuo, Zhibao Dong, Xiping Wang, Beibei Gao, Chunming Zhu, Fei Tuo. "Metagenomics Reveal Correlations Between Microbial Organisms in Soils and the Health of *Populus euphratica*", Frontiers in Microbiology, 2020

Publication

<1 %

47

Zahra Hadian, Majedeh Maleki, Ehsan Feizollahi, Sepideh Alibeyk, Maryam Saryazdi. "Health aspects of geraniol as a main bioactive compound of *Rosa damascena* Mill: a systematic review", Electronic physician, 2020

Publication

<1 %

Exclude quotes On

Exclude matches Off

Exclude bibliography On

SOFT CORAL *Sinularia gibberosa* EXTRACTS ORIGIN PALU BAY, CENTRAL SULAWESI WITH ANTIBACTERIAL AND ANTIOXIDANT ACTIVITY

GRADEMARK REPORT

FINAL GRADE

/100

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11
