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ANTIBACTERIAL ACTIVITY OF SEA GRAPES *(Caulerpa racemosa)* AGAINST *Streptococcusmutans* AND *Shigella dysenteriae*

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D e t a i l A r t i k e l

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K a t a K u n c i

Sea grapes
antibacterial
Streptococcus mutans
Shigella dysenteriae

P e n u l i s K o r e s p o n d e n s i

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A B S T R A C T

The Riau Islands are known as an island group in Indonesia that is famous for its wealth of marine plants. Among the prominent marine flora, sea grape (Caulerpa racemosa) is a marine plant that produces secondary metabolites including alkaloids, saponins, phenolics, and flavonoids which have been proven to have antibacterial properties. Previous research showed that 70% ethanol extract from sea grapes exhibited strong antibacterial activity. However, there is no detailed information regarding the ability of the n-hexane and ethyl acetate fractions of sea grapes as antibacterials. This study aims to examine the antibacterial effects of n-hexane and ethyl acetate fractions from sea grapes against Streptococcus mutans and Shigella dysenteriae. The sea grape extraction process is carried out through the maceration method using 95% ethanol solvent, followed by the fractionation stage using the liquid-liquid extraction method. This fractionation process involves the use of non-polar (n-hexane) and semi-polar (ethyl acetate) solvents. The test method used was disk paper diffusion with varying fraction concentrations: 500 µg/disc, 400 µg/disk, 300 µg/disc, and 200 µg/disk. The positive control for this study used 30 µg/disc of tetracycline, because tetracycline is known as a broad-spectrum antibiotic. Meanwhile, the negative control used 10% DMSO. Findings from the research stated that the n-hexane fraction could not stop the growth of Streptococcus mutans bacteria, while the ethyl acetate fraction was able to inhibit the development of these bacteria. The average diameter at a concentration of 500 µg/disk was 9.2 mm, 400 µg/disk is 8 mm, 300 µg/disc is 7.7 mm, and 200 µg/disc is 6.5 mm. However, neither the ethyl acetate nor n-hexane fractions showed an inhibition zone against Shigella dysenteriae bacteria

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A B S T R A K

Kepulauan Riau dikenal sebagai gugus pulau di Indonesia yang terkenal akan kekayaan tumbuhan lautnya. Di antara flora laut yang menonjol, anggur laut (Caulerpa racemosa) merupakan tanaman bahari yang menghasilkan metabolit sekunder diantaranya alkaloid, saponin, fenolik, dan flavonoid yang telah terbukti memiliki sifat antibakteri. Penelitian sebelumnya menunjukkan bahwa ekstrak etanol 70% dari anggur laut menunjukkan aktivitas antibakteri yang kuat. Namun, belum ada informasi terperinci mengenai kemampuan fraksi n-heksana dan atilasetat anggur laut sebagai antibakteri. Penelitian ini bertujuan untuk menelaah efek antibakteri yang ditimbulkan oleh fraksi n-heksan dan etilasetat dari anggur laut terhadap Streptococcus mutans dan Shigella dysenteriae. Proses ekstraksi anggur laut dilakukan melalui metode maserasi dengan menggunakan pelarut etanol 95%, kemudian diikuti dengan tahap fraksinasi menggunakan metode ekstraksi cair-cair. Proses fraksinasi ini melibatkan penggunaan pelarut non polar (n-heksan) dan semi polar (etilasetat). Metode pengujian yang digunakan adalah difusi kertas cakram dengan variasi konsentrasi fraksi: 500 µg/disk, 400 µg/disk, 300 µg/disk, dan 200 µg/disk. Kontrol positif penelitian ini menggunakan tetrasiklin sebanyak 30 µg/disk, dikarenakan tetrasiklin dikenal sebagai antibiotic dengan spectrum luas. Sedangkan control negatifnya menggunakan DMSO sebanyak 10%. Temuan dari penelitian menyatakan bahwa fraksi n-heksan tidak memiliki kemampuan untuk menghentikan pertumbuhan bakteri Streptococcus mutans, sementara fraksi etilasetat mampu menghambat perkembangan bakteri tersebut..Diameternya rata-rata pada konsentrasi 500 µg/disk adalah 9,2 mm, 400 µg/disk adalah 8 mm, 300 µg/disk adalah 7,7 mm, dan 200 µg/disk adalah 6,5 mm. Namun, baik fraksi etilasetat maupun n-heksan tidak menunjukkan zona hambat terhadap bakteri Shigella dysenteriae.

INTRODUCTION

Indonesia is a country that has a very large island and sea area, with various types of marine plants that can be planted by its inhabitants. One of the islands that is famous for its diversity of marine plants is the Riau Islands in Indonesia. In the waters of Kampung TerihNongsa, Batam City, there are sea grape plants known as Latoh or Lawi-lawi, which are used by coastal communities as vegetables or vegetables. This plant is also believed to have benefits in preventing premature aging and as a treatment for itching.

Sea grapes are a type of green algae that are often found in sand and coral. According to research conducted by(Indarkasi et al., 2023), The study found that "*Caulerpa racemosa* algae has several metabolite compounds such as flavonoids, tannins, steroids, alkaloids, and phenols. These compounds have the ability as antibacterial agents..

Infectious diseases are disease conditions provoked by microorganisms. The microbe that most often causes tooth decay is *Streptococcus mutans*, which gathers to form colonies on the surface of teeth(Prasasti et al., 2021). *Shigella dysenteriae* bacteria constitute a diverse

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and large group of Gram-negative rods, which are usually found in the gastrointestinal tract of humans and animals. These bacteria are the cause of severe diarrhea accompanied by bloody discharge.(Aini, 2018). Other research on sea grapes has been conducted byHainil*et al.,* (2021), Methanol extract from sea grapes showed antibacterial ability against *Staphylococcus aureus* and *Salmonella thypi*. From the results of the study (Luhulima et al., 2022)The antibacterial activity of 70% ethanol extract of sea grapes against *Staphylococcus aureus* showed that at levels of 80% and 60%, it was effective in inhibiting bacterial growth with inhibitory zones of 32 mm and 29 mm in diameter, indicating significant inhibitory ability., in addition to research (Yap et al., 2019)also states that sea grape chloroform extract has strong antibacterial abilities against *Escherichia coli.*

This study evaluated the antibacterial effect of n-hexane fractions and ethyl acetate taken from *Caulerpa racemosa* sea grapes against *Streptococcus mutans* and *Shigella dysenteriae*bacteria by utilizing the disc paper diffusion method .

RESEARCH METHODS

Tools and Materials

Tool

Rotary evaporator, autoclave, incubator, oven, volume pipette, ose needle, caliper, split funnel (Pyrex), erlenmeyer (Pyrex), measuring cup (*Pyrex*), hot plate, LAF (*Laminar air flow*) (*Magnehelic*), micro pipette, porcelain crutches, petri dish, *furnaces, vortex Mixer.*

Material

Ethanol 95%, ethyl acetate, n-hexane, sterileaquadest, chloroform, ammonia 0.05 N, H_2SO_4 (sulfuric acid), Mayer reagent, concentrated HCl, Mg powder, $FeCl_3$ 1%, HCl 1 N, CH_3COOH, $BaCl_2.2H_2O$ 1%, NaCl 0.9%,nutrient agar, tetracycline *disc, Dimethyl sulfoxide.*

Research Procedure

Sample capture and preparation

The sample used as material for this study is sea grapes (*Caulerpa rasemosa*) which grow in the area of Kampung Terih Pantai Nongsa, Riau Islands. A total of 20 kilograms of collected samples have been sorted and washed thoroughly

Plant Identification

Seagrape plants were identified at the Herbarium of Andalas University, Padang to determine the morphology of sea grapes (*Caulerpa racemosa*).

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Extract Creation

Sea grapes *(Caulerpa rasemosa*) weighing 20 kg are cut into small pieces which are then placed in a glass container. The next process involves maceration using a 95% ethanol solvent until all parts of the sea grape are submerged in the solvent. This maceration process lasts for 3 days with daily stirring. Every 3-day interval, the filtrate is filtered, and the pulp is macerated again with ethanol. This maceration process is repeated 3 times. The results of the three maceration stages are combined to evaporate the solvent using a *rotary evaporator* until a thick extract of sea grapes is obtained. The yield, or result obtained, is calculated using the percentage of weight to weight (w/w) using the following formula:

$$\%\text{Yield} = \frac{\textit{weight of viscous extract obtained}}{\textit{sample weight used}} \text{x}100\%$$

Extract characteristics

a. Organoleptic examination
   Identification of extracts is done physically using the senses of smell, sight, and touch to assess the smell, shape, and color of extracts(Hainil*et al.*, 2021)

b. Determination of ash content
   Ekstrak weighed as much as 2 grams, put into porcelain crutches that were heated in the oven at 105 ^{o}Cfor 30 minutes and in-between to constant weight. Then, porcelain crucibles are put into the furnace and heated at 600°C for 7 hours. Next, cool on a new desiccator at the weighed

c. Determination of moisture content
   Empty porcelain dishes are cleaned and dried in the oven at 105°C for 15 minutes, after cooling in a desiccator weighed their weight. A sample weighing 2 grams is placed in a porcelain dish that has been weighed. Then, the sample is dried in the oven at 100-105°C for 3 hours, after cooling in a desiccator for 15 minutes the sample is weighed. This process is repeated until a constant weight is reached.

Phytochemical Screening

1. Alkaloid test
   Ekstrak sea grapes are put into a test tube, and 2 mL ammonia and 2 mL chloroform. After that add 3-5 drops of H_2SO_4 concentrated, shake, and leave to form two layers. Take the top layer, transfer it to a test tube, add 4-5 drops of reagent Mayer, observe if there is a precipitate of white berate sample containing alkaloids.
2. Flavonoid Test
   Mix the sea grape extract into 20 mL of aquadest into a test tube then heat for 5 minutes. Next, this mixture plus 1 mL of HCl concentrated and 0.2 g of powder Mg. If there is a discoloration to dark red (magenta) within 3 minutes, this result indicates the presence of flavonoids.
3. Phenolic Test

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In the test tube insert ekstract sea grapes are inserted, then add 10 drops of $FeCl_3$ 1%. Changes in the color of the solution to green, red, purple, blue, or solid black are positive indicators of the presence of phenolic compounds in the extract.

4. Saponin Test
   Stir thesea grape extract into a test tube followed by the addition of 10 mL of hot water. After the cooling process, the mixture is shaken vigorously for 10 seconds. The presence of saponins will be characterized by the formation of foam that lasts no less than 10 minutes after the shaking process.

5. Test Steroids/Terpenoids
   Seagrape extract is taken, then 10 drops of CH_3COOH and 2-3 drops of H_2SO_4 are added. After that, stir gently and leave for a few minutes. If a red or purple color appears, it indicates a positive result for the terpenoid. Conversely, if a blue color is formed, it signals a positive result for the steroid.

Fractionation

The concentrated ethanol extract is separated using a separate funnel with the addition of water and n-hexane (in a ratio of 1:2), which is then shaken to form two separate layers: the n-hexane layer and the water layer. The n-hexane layer is separated from the water. A layer containing a mixture of ethanol and water is fed back into the split funnel, while the n-hexane layer is evaporated with a rotary evaporator to produce a concentrated fraction of n-hexan which is then weighed.

The ethanol-water mixture fraction is then separated again using ethyl acetate. After shaking, the fraction splits into two separate layers: an ethyl acetate layer and an ethanol-water layer. The layer containing a mixture of ethanol and water is fed back into the split funnel, while the ethyl acetate layer is evaporated with a rotary evaporator to produce a concentrated fraction of ethyl acetate. The weight of this ethyl acetate fraction is then weighed(Marliza et al., 2022)

Antibacterial activity testing

Antibacterial activity testing of n-hexane fraction and ethyl acetate fraction of sea grapes using disc paper diffusion method. Extract concentration fractions 500 µg/disk, 400 µg/disk, 300 µg/disk, and 200 µg/disk. Next, the media nutrien agar (NA) each poured as much as 20 ml into a petri dish, and let it solidify. Then add a 30 µ L bacterial suspension using a micropipette and then scratch it using a *cotton bud* steril zigzag on the media until it fills the surface of the media. 10 µL of each fraction extract concentration are taken and then placed on c akram paper and then attached to the surface of the agar. This action is repeated three times. In this test, the positive control used tetracycline as much as 30 µg/disk, and the negative control used DMSO as much as 10%. After that, the petri dish is placed in an incubator for 24 hours at a temperature of 37°C. Then, observations and measurements were made of the diameter of the hampered area using a caliper.

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RESULTS AND DISCUSSION

Extraction is carried out through maceration techniques, which are useful for extracting heat-sensitive compounds or in samples whose compounds have not been identified (Kiswandono, 2017).This method uses 95% ethanol solvent, which was chosen because of its properties as a universal solvent that can dissolve most types of secondary metabolites and is non-toxic, and is safe to use according to Harborne (1987). The results of the resulting extract are:

$$\%\text{Yield}=\frac{425\ \text{grams}}{20.000\ \text{grams}}x\ 100\%$$

$$= 2{,}12\ \%$$

Extract characterization is the initial stage used to assess the quality of an extract in a specific way (Depkes RI,2000). The results of the organoleptic examination showed sea grape extract in thick form, brownish-green in color, fishy smell, and salty taste **(Figure 1),**and the total ash content value was 16.91% **(table 1)** while the water content result of 19.87%**(table 2).**

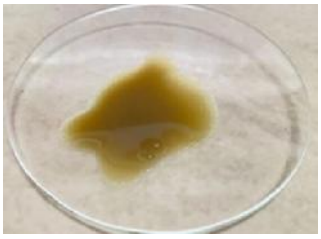

Figure 1. Organoleptic examination

Table 1. Ash content check

(A)	**(B)**	**(C)**			
		Repetition I	**Repetition II**	**Repetition III**	**Ash content (%)**
53,885 g	55, 215 g	54.270 g	54.110 g	54, 110 g	16,91%

Ket: A (Weight of empty caucus), B (Weight of crucible + extract before in oven), C (Weight of crucible + extract after in oven)

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Table 2. Moisture content check

(A)	(B)	(C)			
		Repetition I	Repetition II	Repetition III	Kadar Air (%)
30.205 g	32, 645 g	32,540 g	32,160 g	32,160 g	19,87 %

Ket: A (Weight of empty caucus), B (Weight of crucible + extract before in oven), C (Weight of crucible + extract after in oven)

The concentrated extract of sea grapesis then processed using a fractionation technique with liquid-liquid extraction. The purpose of this fractionation is to separate the main groups of compounds based on their polarity properties. Nonpolar compounds tend to dissolve in solvents that are also not polar, while polar compounds are more likely to dissolve in polar solvents. Therefore, this fractionation is carried out using two solvents that have different polarities, namely n-hexane (nonpolar) and ethyl acetate (semipolar). The fractionation results showed that the fraction from n-hexan extract weighed 1.705 grams and from ethyl acetate weighed 3.115 grams. However, the difference in weight of the resulting fractions of the two solvents did not affect antibacterial activity.

In this study, phytochemical analysis revealed the presence of secondary metabolites such as alkaloids, flavonoids, and saponins on the ethyl acetate fraction. While in the n-hexane fraction, no secondary metabolite compounds were found (see Table 3). Alkaloids are known to have antibacterial properties because they have quaternary aromatic groups that can interact with DNA, and the ability of alkaloids to disrupt the integrity of peptidoglycan components in bacterial cells (Sholekah et al., 2017). Flavonoids, which are synthesized by plants in response to microbial infections, have also proven effective as antibacterial agents capable of fighting various types of microorganisms. Flavonoids can cause protein denaturation inside microbial cells, which also supports antibacterial activity.

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Table 3. Seagrapefraction screening results (*Caulerpa racemosa*)

No.	Parameter	Fraksi n-Heksan	FraksiEtilAsetat
1.	Alkaloids	(-) Negative	(+) White precipitate
2.	Flavonoids	(-) Negative	(+) Dark red color
3.	Saponins	(-) Negative	(+) Permanent foam/foam
4.	Phenolic	(-) Negative	(-) Negative
5.	Terpenoids/Steroids	(-) Negative	(-) Negative

The method applied in testing antibacterial properties on certain parts of sea grape extract is through diffusion techniques using disc paper. The diffusion technique was chosen because it allows the observer to see whether the bacteria are growing or not, making it easier to monitor the development of the bacteria being tested. The size of the diameter that inhibits the growth of these bacteria can be identified from the clear zone that appears around the disc.

The results obtained on the ethyl acetate fraction of sea grapes can inhibit the growth of *Streptococcus mutans* bacteria, with the formation of an inhibitory zone around the disc. At a concentration of 500 µg/disk 9.2 mm is obtained, a concentration of 400 µg/disk is obtained 8 mm, at a concentration of 300 µg/disk is obtained 7.7 mm, and a concentration of 200 µg/disk is obtained 6.5 mm.

Table 4. Results of inhibition zone measurement of antibacterial activity testri sea grape fraction against *Streptococcus mutans*bacteria

Sample	Concentration	Diameter of the inhibitory zone (mm)				Information
		I	II	III	Average	
Faction n-Hexan	500 µg/disk	0	0	0	0	-
	400 µg/disk	0	0	0	0	-
	300 µg/disk	0	0	0	0	-
	200 µg/disk	0	0	0	0	-
	Kontrol (+) Tetrasiklin 30 µg/disk	35	35,2	35	35	Very powerful
	DMSO 10%	0	0	0	0	-
Fraction	500 µg/disk	9	9,5	9,4	9,2	Keep

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Ethyl Acetate	400 µg/disk	7,9	8,3	8	8	Keep
	300 µg/disk	7,7	7,6	7,8	7,7	Keep
	200 µg/disk	6,8	6,4	6,5	6,5	Keep
	Control (+) Tetracycline 30 µg/disk	35	35,2	35	35	Very powerful
	DMSO 10%	0	0	0	0	-

Table 5. Results of the inhibition zone measurement test of antibacterial activity of sea grape fraction against bacteria*Shigella dysenteriae*

Sample	Concentration	Diameter of the inhibitory zone (mm)				Information
		I	II	III	Average	
Faction n-Hexan	500 µg/disk	0	0	0	0	-
	400µg/disk	0	0	0	0	-
	300 µg/disk	0	0	0	0	-
	200 µg/disk	0	0	0	0	-
	Control (+) Tetracycline 30 µg/disk	27,6	27,8	27,7	27,6	Very powerful
	DMSO 10%	0	0	0	0	-
Faction Ethyl Acetate	500 µg/disk	0	0	0	0	-
	400 µg/disk	0	0	0	0	-
	300 µg/disk	0	0	0	0	-
	200 µg/disk	0	0	0	0	-
	Control (+) Tetracycline 30 µg/disk	27,5	27,9	27,7	27,7	Very powerful
	DMSO 10%	0	0	0	0	-

It is thought that chemicals that tend to be semipolar, such as flavonoids present in the ethyl acetate fraction, may exhibit effective abilities as antibacterial agents. This is because flavonoids, which are included in the phenol category, have been shown to have antibacterial

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properties by interfering with bacterial metabolic processes through damage to cell wall structure and changes in the shape of proteins present in bacteria.

Compared to the larger positive control diameter, namely tetracycline of 30 µg / disk which reaches 35 mm, this is due to the nature of tetracycline which is an antibiotic with a wide range, able to inhibit or even kill the growth of bacteria both Gram positive and Gram negative (Muharni *et al*., 2017).In contrast, a negative control, i.e. 10% DMSO, does not indicate a resistance zone. Evaluation of antibacterial activity can be measured from the diameter of the resistance zone which can be grouped into 4 categories, where the diameter of the resistance zone of 20 mm is considered to have very strong activity. Factors affecting antibacterial activity include extract concentration, composition of secondary metabolite compounds, type of bacteria inhibited, and diffusion power of extract(Sulaiha et al., 2022).

The results showed that the ethyl acetate fraction has the property to inhibit the growth of *Streptococcus mutans*bacteria with an inhibition zone that has a medium size. On the other hand, the n-hexan fraction showed no inhibition zone against the growth of *Streptococcus mutans* and *Shigella dysenteriae* bacteria. The inability of the n-hexan fraction to form an inhibitory zone in*Shigelladysenteriae* bacteria is caused by the inability of the active substance in the fraction topenetrate the cell wall of the Gram negative bacteria

The difference in bacterial sensitivity to antibacterial substances can be influenced by the structure of the cell wall. Gram-negative bacteria tend to be more susceptible to physical disorders because they have a small peptidoglycan coating and do not contain teicoic acid. In contrast, gram-positive bacteria have a more complex cell wall structure with more peptidoglycan, fewer lipids, and contain water-soluble teicoic acid, making them polar.

The structure of the outer membrane of gram-negative bacteria consists of phospholipids (inside) and lipopolysaccharides (outside), which makes them nonpolar. This makes gram-negative bacteria more difficult to expose to antibiotics or antibacterial substances due to differences in the structure of their cell walls.

CONCLUSION

From the research that has been done, it can be concluded that :

1. The ethyl acetate fraction of sea grapes showed a moderate degree of potency as an antibacterial agent against *Streptococcus mutans* bacteria, while the n-hexan fraction showed no antibacterial activity against the same bacteria.

2. Neither the n-hexan fraction nor the ethyl acetate fraction of *the sea grape Caulerpa racemosa* showed antibacterial activity against *Shigella dysenteriae* bacteria based on the results of the studies conducted.

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