Exploring the Antibacterial Potential of Water Hyacinth (*Eichhornia crassipe* (Mart.) Solm) Against *Staphylococcus epidermidis* and *Propionibacterium acnes*

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Abstract: Water hyacinth (*Eichhornia crassipes* (Mart.) Solm) is recognized for its antibacterial, antipyretic, anti-inflammatory, and diuretic properties, containing various active compounds such as saponins, flavonoids, polyphenols, and alkaloids. The objective of this study was to evaluate the antibacterial activity against *Staphylococcus epidermidis* and *Propionibacterium acnes* a 70% ethanolic extract of water hyacinth from Lake Toba. The solid diffusion method was employed to determine the minimum inhibition zone, using tetracycline as a positive control and 10% DMSO as a negative control. The results indicated significant antibacterial activity of the extract against both bacteria. For *Staphylococcus epidermidis*, inhibition zones measured 10.59 ± 0.07 mm (25%), 11.41 ± 0.04 mm (50%), 12.43 ± 0.10 mm (75%), and 14.44 ± 0.01 mm (100%), with a minimum inhibitory concentration (MIC) of 25%. In comparison, the inhibition zones for *Propionibacterium acnes* were 11.20 ± 0.08 mm (25%), 11.44 ± 0.01 mm (50%), 14.51 ± 0.04 mm (75%), and 19.37 ± 0.12 mm (100%), with an MIC of 20%. These findings highlight the remarkable antibacterial efficacy of water hyacinth extract at these concentrations and support its potential pharmacological and therapeutic applications.

SCIENCE AND TECHNOLOGY PUBLICATIONS

1 INTRODUCTION

Water hyacinth is well-known for causing major environmental harm and imposing a major management-related financial burden. Nevertheless, it presents significant opportunities if effectively utilized, particularly by rural areas. Variables include high temperatures, eutrophic conditions, and other environmental factors drive the plant to flourish at places it has been introduced to. Considered to be one of the most troublesome invading weeds worldwide, white horehound is white Its control and eradication are quite difficult and call for an all-encompassing plan and community active participation (Harun et al., 2021). By reducing oxygen levels and preventing sunlight required for photosynthesis in submerged aquatic plants, the dense mats created by water hyacinth disturb water flow and lower fish populations. Furthermore, these mats provide ideal circumstances for the spread of disease-carrying organisms such as mosquitoes, therefore aggravating public health issues (Murugesh et al., 2023). Water hyacinth's expansion in Lake Toba has blocked sunlight, lowered fish counts, and hampered local livelihoods depending on the lake's resources. Dense mats of the plant develop on the surface of the lake, upsetting the aquatic habitat and thereby reducing the lake's ecological and aesthetic worth (Tobing & Harahap, 2024)

Water hyacinth is clearly valuable as a source of bioactive compounds and in the field of phytoremediation, despite various challenges. The plant is quite fit for bioremediation because of its fast development rate and great biomass. From water bodies, it can efficiently absorb heavy metals and other pollutants (Peng et al., 2020). Water hyacinth's phytochemicals contains several metabolites, such as vitamins, tannins, saponins, terpenoids, phenolic compounds, lignins, flavonoids, alkaloids, and sterols. With the occurrence of all these secondary metabolites, a wide range of therapeutic values has

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been attributed to the plant, of which the alkaloids, phenolic compounds, triterpenoids, flavonoids, tannins, and saponins of the plant exhibited promising pharmacological effects. (Gebrehiwot et al., 2022)

The search for antimicrobial drugs has been heightened by the developing issue of antibiotic resistance. Two known to be causes of skin infections and inflammatory illnesses including acne vulgaris are *Staphylococcus epidermidis* and *Propionibacterium acnes*. Gram-positive bacterium *S. epidermidis* uses chances to infect patients with compromised immune systems and creates biofilms on medical equipment, therefore complicating therapy (Nguyen, 2017). Gram-positive bacterium *P. acnes* causes inflammation and helps comedones to grow, therefore aggravating acne (Dreno et al., 2015).

Previous investigations have indicated that water hyacinth extracts have antibacterial qualities and can fight several kinds of microbes rather successfully. Indicating its natural antimicrobial action, Asmare and Gure (2019) showed that extracts obtained from water hyacinth showed considerable antibacterial activities against several infections. Recent research revealed how well methanolic and ethanolic extracts made from water hyacinth leaves inhibited the growth of bacteria—more especially, *S. aureus* and *E. coli.* These results show the possible antibacterial properties of water hyacinth extracts (Jouda et al., 2016).

Flavonoids and alkaloids are among the phytochemical components whose ability to generate antimicrobial actions via several channels is well known. Flavonoids can mess with bacterial cell membranes and stop nucleic acid synthesis. Conversely, alkaloids can stop bacterial protein production (Cushnie & Lamb, 2011). This investigation is to investigate the particular effects of these compounds on *S. epidermidis* and *P. acnes* in order to acquire a deeper knowledge of their possible as alternative antibacterial agents.

The dual issue of controlling the invading spread of water hyacinth and the pressing need for new antibacterial drugs makes this work current and important. Using water hyacinth as a source of antibacterial compounds not only offers a possible fix for the environmental problems brought about by this invading species, but also supports the more general effort against antibiotic-resistant bacteria. Still, there are few thorough investigations comparing its efficacy against *S. epidermidis* and *P. acnes.* This work aims to close this gap by evaluating the antibacterial activity of ethanol extracts obtained from water hyacinth from lake Toba, North Sumatera, Indonesia against these two medically important infections.

2 MATERIAL AND METHOD

2.1 Material

The test microbes used were *Staphylococcus epidermidis* and *Propionibacterium acnes*, which were obtained from the Microbiology Laboratory, Faculty of Pharmacy, USU. Mueller Hilton Agar (Oxoid) was used as the growth medium. The test material, water hyacinth (*Eichhornia crassipes*), was sourced from Lake Toba Haranggaol. The solvent used in the maceration process was 70% ethanol. For phytochemical screening, various reagents and substances were used, including aquadest (Brataco), 2N HCl, Dragendorff reagent, Mayer reagent, 70% ethanol, Mg, concentrated HCl, anhydrous acetate, chloroform, and concentrated H2SO4 (Lieberman-Burchard). Antibiotic discs, tetracycline, and 0.9% NaCl were used for the microbial test suspension media. Tetracycline was used as the positive control, while DMSO served as the negative control

2.2 Method

The leaves of the freshwater hyacinth, collected from Lake Toba Haranggaol, North Sumatera, Indonesia were identified as *Eichhornia crassipes* (Mart.) Solms by the Herbarium Medanense Laboratory (MEDA), North Sumatera University, Indonesia with determination number 6342/MEDA/2021. After collection, the leaves were cleaned and dried away from direct sunlight to preserve their secondary metabolites, followed by slicing. After that prepared the powder from the dried leaves using the maceration technique. The solution was filtered via filter paper, then evaporated on a rotary evaporator to concentrate the extract.

Water hyacinth extract were tested for antimicrobial activity using the disc diffusion method to find MIC at different concentrations like 25%, 50%, 75%, and 100%. The MIC against *Staphylococcus epidermidis* and *Propionibacterium acnes* was also determined by the solid dilution method at a concentration of 25%, 20%, 15%, 10%, and 5%.

2.3 Preparation of Water Hyacinth Extract

Water hyacinth was obtained from Lake Toba Haranggaol and dried out of direct sunlight to avoid damaging the secondary metabolites. To acquire 5 kg of dried powder, the dried sample (simplicia) was ground with a blender and sieved through a 60-mesh sieve. This material was macerated with 25 liters of 70% ethanol, as ethanol concentrations exceeding 70% are less effective in dissolving low molecular weight flavonoid compounds. The maceration process entailed the powder being soaked in ethanol for three days, with intermittent stirring. The resulting solution was filtered through flannel cloth and re-filtered using filter paper, followed by re-maceration until it was clear. The filtrate was evaporated in a vacuum rotary evaporator and subsequently in a water bath to produce a thick extract. This extract was subsequently stored in a dark glass container. (Jimmy et al., 2019).

2.4 The Ethanol Examination of the Extract

Testing of the extract for ethanol was performed to ascertain that the extract to be tested on bacteria was ethanol-free. Therefore, the inhibitory activity could not be attributed to residual ethanol in the extract but to the secondary metabolites of the simplicia. The test was conducted by gradually adding 1N NaOH to 0.5 g of 70% ethanol extract of water hyacinth leaves, then allowing it to settle for 3 minutes, then adding 2 mL of 0.1N iodine will result in a yellow precipitate within 30 minutes, with an iodoform odor if the extract still contains ethanol. (Saturño,et al, 2019).

2.5 Phytochemical Screening of Water Hyacinth Extract

The chemical compounds in water hyacinth were identified through qualitative phytochemical screening. The subsequent assessments were implemented during the examination (Baehaki et al., 2023):

2.5.1 Alkaloid Identification

The mass was immersed in 20 mL of chloroform and 5 mL of 25% ammonia after 1 g of extract and powder were added. Stir and heat the mixture over a water boiler, and subsequently filter it. Vaporize the filtrate until it is half filled. Pour the remaining evaporation into a test tube and add 1 mL of 2N hydrochloric acid. Shake the tube and allow it to form two layers. The clear layer was divided into three test tubes (Tubes I, II, and III) with equal quantities of Mayer's reagent in Tube I, Dragendorf's reagent in Tube II, and Bouchardat's reagent in Tube III. The formation of a white precipitate with Mayer's reagent, a brown-black precipitate with Bouchardat's reagent, and a scarlet precipitate with Dragendorf's reagent were indicators of the presence of alkaloids.

2.5.2 Identification of Flavonoids

Three mL of 70% ethanol was mixed with about 1 mL of powder and it was stirred, warmed and then shaken once more. The solution was then filtered. The filtrate was added with 2 drops of concentrated HCl and 0.1 g Mg. The colours red, orange and green showed up in the ethanol layer, which indicated the existence of flavonoids.

2.5.3 Identification of Steroids and Terpenoid

For a period of two hours, 20 mL of ether was combined with 2 g of powder and extract. Next, it was filtered and evaporated in an evaporation dish until residue was obtained. The residual was subsequently combined with 2 drops of anhydrous acetate and 2 mL of chloroform. Subsequently, it was transferred to a test tube and gradually introduced with 1 mL of concentrated H_2SO_4 (Lieberman-Burchard) through the tube wall. The presence of terpenoids was indicated by the formation of a purple ring, while the presence of steroids was indicated by a green color.

2.5.4 Tannin Identification

Ethanol was added to 2 g of powder until it was completely submerged. Next, 1 mL of the solution was transferred to a test tube and mixed with 2-3 drops of a 1% $FeCl_3$ solution. The formation of a blue-black or green color was indicative of a positive outcome.

2.5.5 Identification of Saponin

A test vial was filled with 1 g of powder and extract, which was subsequently added to 10 mL of hot water, cooled, and vigorously shaken for 10 seconds. The presence of saponins was indicated by the formation of stable froth of 1–10 cm within less than 10 minutes, which did not dissipate upon the addition of 1 drop of 2N hydrochloric acid.

2.6 Antibacterial Activity

The antibacterial activity was evaluated using the disc diffusion technique. 0.1 mL of bacterial suspension was applied to petri dishes containing sterile Mueller Hinton Agar (MHA) media. Test solutions at concentrations of 100%, 75%, 50%, and 25% were applied to paper discs and then placed on the agar surface that had been previously inoculated with bacteria. The plates were placed in an incubator set at a temperature of 37°C for a duration of 24 hours. The antibacterial activity was assessed by quantifying the diameter of the transparent areas surrounding the discs using calipers (EUCAST, 2019).

The solid dilution method was utilized to determine the minimum inhibitory concentration (MIC). Bacterial proliferation was detected starting from the minimum concentration of the extract that resulted in the formation of zones of inhibition. Following the acquisition of the inhibition zone results, the minimum inhibitory concentration (MIC) was established using the indicated concentrations. Solutions (1 mL), bacterial suspension (1 mL), and MHA medium were combined and placed in petri dishes. The solution was placed in a controlled environment at a temperature of 37°C for a duration of 24 hours. The minimum inhibitory concentration (MIC) refers to the lowest concentration of the antibacterial solution that effectively prevented the development of microorganisms. (Thakur et al., 2018)

3 RESULT AND DISCUSSION

3.1 Extraction and Pytochemical Screening

The water hyacinth was extracted using the maceration process, which was selected for its simplicity, ease of use, and non-destructive effects on the sample's constituents. Maceration is the process of immersing powdered simplicia in a solvent that is appropriate, and then extracting the active ingredients at room temperature. The solvent utilized for this technique was 70% ethanol. Ethanol concentrations higher than 70% have been found to reduce the extraction efficiency of total flavonoids. This is because higher ethanol concentrations are less effective at dissolving low molecular weight flavonoid compounds. This observation aligns with the findings of Sudirman et al. (2024).

Recent research has investigated several methods and compounds for extracting phytochemicals from water hyacinth, focusing on the efficiency and productivity of various techniques. Nguyen et al. (2019) examined the effectiveness of using ultrasound-assisted extraction for the extraction of flavonoids from water hyacinth. As observed in their study, UAE showed a better extraction yield and was efficient compared to the conventional method of maceration. The UAE technique utilizes ultrasonic waves to enhance the penetration of the solvent into the plant material, offering a more efficient extraction process.

Kumar and Singh, in their work 2020, have studied different solvent systems for flavonoid extraction from water hyacinth. It has been observed that the solution containing ethanol and water in a ratio of 50:50 showed maximum content of flavonoids. This suggests that a balanced-polarity solvent system can increase the efficacy of extraction. This finding supports the principle that extraction of flavonoids requires ethanol of a middle level, about 50-70%, since this concentration exhibits moderate polarity.

The maceration technique in this study has resulted in a yield of 160 grams of the concentrated extract from 5 kg water hyacinth powder, which works out to approximately 32% of the extract. The yield obtained in this study is comparable to the results published by Nguyen et al. (2019), who used ultrasound-assisted extraction to obtain a yield of 35%, and Kumar and Singh, who in 2020 obtained 30% yield utilizing a mixture of ethanol and water in a ratio of 50:50. These comparisons indicate that, although maceration is an effective and easy technique, other processes like UAE could give slightly higher yields and efficiency.

The 70% ethanol extract of water hyacinth did not exhibit any detectable ethanol in the ethanol-free test, as evidenced by the absence of an iodoform odor and the absence of yellow precipitate formation. This confirmation indicates that the extract is able to advance to the subsequent stage. The test was crucial due to ethanol's antiseptic characteristics, which may inhibit the growth of microorganisms. Thus, the lack of ethanol guaranteed that any inhibitory effects were solely caused by the plant's chemical components rather than any remaining ethanol.

This discovery is consistent with recent investigations that have shown that 70% ethanol is efficient in extracting active chemicals while limiting the amount of leftover ethanol. An investigation conducted by Lim et al. (2022) demonstrated that 70% ethanol exhibited the most effective antibacterial

activities while minimizing the presence of residues that could potentially interfere with following testing stages. A separate investigation has verified that extracts made using a 70% ethanol solution exhibited notable effectiveness in maintaining the bioactive components, which are accountable for the antibacterial characteristics, without any interference from residual ethanol (Nguyen et al., 2019).

Phytochemical screening was done on both water hyacinth powder and its 70% ethanol extract. Tests were positive for the presence of various bioactive compounds, including alkaloids, tannins, saponins, and steroids in both powder form and ethanol extract. The results of the phytochemical screening of the powdered form and the 70% ethanol extract of water hyacinth are summarized in Table 1.

Table 1: Phytochemical screening of powder and 70% ethanol of water hyacinth extract.

Chemical compounds	Result	
	Extract	Powder
Flavonoids	-	-
Alkaloids	+	+
Tanins	+	++
Saponin	++	+
Steroid	++	+
Triterpenoids	-	-

(-): indicates the absence of compounds
(+): indicates the presence of compounds

Results for the saponin test were positive in forming a stable foam of about 1 cm in height. This foam persisted even after the injection of 2N HCl. The test for triterpenoids was positive; it was indicated by the formation of a purple ring.

The tannin test was positive as a black-green color developed following the addition of 1% FeCl3. The flavonoid test was also positive as an orange-yellow color developed after the addition of 1N NaOH in the testing of flavonoids. However, the results turned out to be negative for alkaloids on both powder form and extract. On the contrary, Mayer's reagent did not form a white precipitate. Dragendorf's and Bouchardat's reagents did not form red and brown precipitates, respectively. Absence of the appearance of a green tint indicates negativity in steroid testing.

Ben Bakrim et al., (2021) conducted a recent investigation where they found that water hyacinth extracts had comparable phytochemical profiles.

Their investigation substantiated the existence of saponins, tannins, and flavonoids, while also documenting discrepancies in alkaloid levels based on the geographic source of the specimens. This diversity agrees with the findings reported by Wang et al. 2020, which also reported adverse outcomes for both alkaloids and steroids. They proposed that environmental parameters related to soil composition, water quality, and climate conditions generally have a strong bearing on phytochemical composition in the water hyacinth.

Moreover, a study conducted by Yan et al. (2022) emphasized the significance of various extraction techniques in identifying the amount and composition of phytochemicals. The researchers discovered that ethanol extracts contained a wide range of bioactive chemicals, but specific alkaloids were more effectively extracted using other solvents like methanol or chloroform. These results confirm that using ethanol extraction with a concentration of 70% effectively separated tannins, saponins, and flavonoids, but did not isolate alkaloids or steroids.

3.2 Antibacterial Activity

3.2.1 Inhibition Zone Diameter

In the antimicrobial activity test of the 70% ethanol extract of water hyacinth using the disc diffusion method, each disc was impregnated with 20 µL of extract at concentrations of 25%, 50%, 75%, and 100%. The 10% DMSO was chosen as the solvent because it can dissolve both polar and nonpolar substances and does not possess antibacterial properties, ensuring that any observed antimicrobial effects are due to the extract itself

The results showed a clear concentration-dependent increase in the inhibition zones, with higher concentrations producing larger zones of inhibition against *Staphylococcus epidermidis* and *Propionibacterium acnes*. Detailed data on the inhibition zones can be seen in Table 2, while antimicrobial activity of ethanol extract of water hyacinth can bee seen in Figure 1**,** highlighting the inhibition zones against *Staphylococcus epidermidis* and *Propionibacterium acnes*.

Table 2 displays the measuring results of the inhibition zone diameter of the 70% ethanol extract of water hyacinth against *Staphylococcus epidermidis* and *Propionibacterium acnes*. The obtained inhibition zone diameters of *Staphylococcus epidermidis* were 10.59± 0.07 mm, 11.41±0.04 mm, 12,43±0.10mm, and 14,44±0.01 mm for concentrations of 25%, 50%, 75%, and 100% respectively. The positive control, tetracycline, successfully suppressed and eradicated Gram-positive bacteria, whereas the negative control, 10%

Table 2: Antimicrobial Activity Test Results of 70% Ethanol Extract of Water Hyacinth Against *Staphylococcus epidermidis* and *Propionibacterium acnes.*

Concentration	Inhibition Zone Diameter (mm)		Inhibitory response
	Staphylococcus epidermidis	*Propionibacterium acnes*	
WHE 25%	10.59± 0.07	11.20± 0.08	Moderate
WHE 50%	11.41±0.04	11.44±0.01	Moderate
WHE 75%	12,43±0.10	14,51±0.04	Moderate
WHE 100%	14,44±0.01	19,37±0.12	Moderate
Tetracycline	28,53±0.14	26,31±0.05	Strong
DMSO 10%	-	-	None

(-): No inhibition zone formed; WHE: Water Hyacinth Extract
Data are means of three replicates (n = 3) ± standard error.

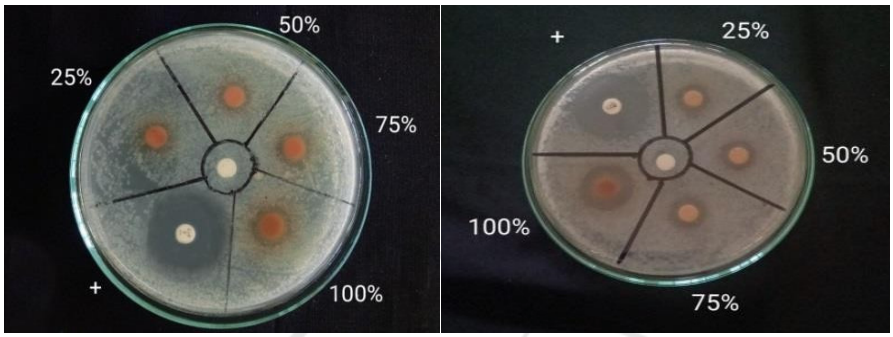

Figure 1: Inhibition Zone of Ethanol Extract of Water Hyacinth Against *Staphylococcus epidermidis* (right) and *Propionibacterium acnes* (left).

DMSO, had no inhibitory effects due to the absence of antibacterial characteristics in DMSO. Niu et al. (2017) classified variation in inhibition zone diameter into three categories: mild activity (0-9 mm), moderate activity (10-14 mm), and strong activity (>15 mm). The results indicate that the 70% ethanol extract of water hyacinth, at concentrations of 25%, 50%, 75%, and 100%, has moderate activity. In contrast, the positive control (tetracycline) demonstrates significant activity.

The measurement results of the inhibition diameter of 70% ethanol extract of water hyacinth against *Propionibacterium acnes* as shown in Table 1 were 11.20± 0.08 mm at 25% concentration, 11.44±0.01 mm at 50% concentration, 14,51±0.04 mm at 75% concentration, and 19,37±0.12 mm at 100% concentration. The negative control yielded negative results compared to the positive control. The positive control (tetracycline) was effective in inhibiting and killing Gram-positive bacteria, while the negative control (10% DMSO) did not show any inhibition as DMSO does not have antibacterial properties. These results categorize the 70% ethanol extract of water hyacinth as having moderate activity at concentrations of 25%, 50%, and 75%, and as having strong activity at 100% concentration. The positive control (tetracycline) is categorized as having strong activity. Gram-positive bacteria tend to be more sensitive to antibacterials due to their simpler cell wall structure compared to Gram-negative bacteria, allowing antibacterial compounds to enter Gram-positive bacterial cells more easily. Gram-positive bacteria have cell walls with more peptidoglycan, fewer lipids, and contain polysaccharides (teichoic acids) (Alhumaid et al., 2021).

Triterpenoid chemicals suppress bacterial growth by interacting with the porins, which are transmembrane proteins located in bacterial cell walls and which have been shown to ultimately result in the formation of robust polymer bonds leading to structural damage of the porins. This phenomenon results in cellular damage that decreases the permeability of the cell wall, which eventually leads to a lack of nutrients and hence inhibiting or causing the death of bacterial growth. (Wrońska et al., 2022). Similarly, steroids demonstrate antibacterial activity through their interaction with membrane lipids, resulting in the release of bacterial liposomes. The interaction between cell membrane phospholipids and lipophilic substances renders the membranes permeable, leading to a decrease in membrane integrity and resulting in cell lysis (Yan et al., 2022)

Susceptibility to antibacterials depends on the type of cell wall construction; high susceptibility is seen in Gram-positive bacteria because of the simpler

makeup of the cell wall when compared with the complex makeup in Gram-negative bacteria. Other factors that may influence antibacterial assays include the quantity of the extract, the presence of other secondary metabolites, incubation time, room conditions, sterility of equipment, the number of persons in the room, and how well asepsis is maintained by the experimenter (Breijyeh et al., 2020. These variables are essential for guaranteeing precise and replicable outcomes in antibacterial research.

3.2.2 Minimum Inhibitory Concentration (MIC) Test

The minimum inhibitory concentration, MIC, was determined using the solid dilution test. This test was carried out to establish the lowest concentration of the sample that exhibited antibacterial activity against the test microorganisms. The minimum inhibitory concentration, MIC of the water hyacinth extract concentration, was determined, whereby the zone of inhibition considered to be the smallest was 25% and then followed by further reduction to 20%, 15%, 10%, and lastly 5%.

Table 3: Minimum Inhibitory Concentration (MIC) Test Results of 70% Ethanol Extract of Water Hyacinth Against *Staphylococcus epidermidis* and *Propionibacterium acnes.*

Concentration	Result	
	S.aureus	*P.acnes*
WHE 25%	-	-
WHE 20%	+	-
WHE 15%	+	+
WHE 10%	+	+
WHE 5%	+	+
Negative Control (MHA Media)	-	-
Positive Control (Media + Bacteria)	+	

WHE: Water Hyacinth extract
(+) Indicates bacterial growth
(-) Indicates no bacterial growth

The study demonstrated that the 70% ethanol extract of water hyacinth (Eichhornia crassipes) exhibited significant antibacterial activity against Staphylococcus aureus, with a Minimum Inhibitory Concentration (MIC) determined at 25%. Bacterial growth was observed at lower concentrations (5%, 10%, 15%, and 20%), indicating that higher concentrations are necessary for effective inhibition. This finding aligns with previous research highlighting the potent antibacterial properties of water hyacinth extracts against pathogens (Kavinkumar et.al., 2023)).

Similarly, the extract showed effectiveness against *Propionibacterium acnes*, with an MIC of 20%. Growth was detected at lower concentrations (5%, 10%, and 15%) but not at 20% and 25%. This suggests that the extract can effectively inhibit the proliferation of *P. acnes*, a key contributor to acne development. The results indicate that the bioactive compounds in water hyacinth may disrupt bacterial cell membranes or metabolic processes, preventing further growth (Padmarini et.al, 2022). In conclusion, the findings suggest that the 70% ethanol extract of water hyacinth has potential as a natural antibacterial agent against both Staphylococcus aureus and Propionibacterium acnes. Further research is needed to identify specific bioactive compounds responsible for this activity and to explore their potential applications in treating bacterial infectionstions in treating bacterial infections.

4 CONCLUSION

The 70% ethanol extract of water hyacinth (*Eichhornia crassipes*) demonstrated significant antibacterial activity against *Staphylococcus epidermidis* and Propionibacterium *acnes*. For *S. epidermidis*, the inhibition zones were 10.59 ± 0.07 mm at a concentration of 25%, 11.41 ± 0.04 mm at 50%, 12.43 ± 0.10 mm at 75%, and 14.44 ± 0.01 mm at 100%. The minimum inhibitory concentration (MIC) was determined to be 25%, as bacterial growth was effectively inhibited at this concentration. Similarly, for P. acnes, the inhibition zones measured 11.20 ± 0.08 mm at 25%, 11.44 ± 0.01 mm at 50%, 14.51 ± 0.04 mm at 75%, and 19.37 ± 0.12 mm at 100%. The MIC values were 20%, indicating that the extract exhibited strong antibacterial efficacy at these concentrations.

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