

Antibacterial And Antifungal Activity of *Solanum Melongena L.* (Eggplant) Leaf Extract on Selected Oral Pathogens

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Abstract -This study investigates the antibacterial and antifungal activities of *Solanum melongena L.* (eggplant) leaf extract against oral pathogens *Streptococcus mutans* and *Candida albicans*. Phytochemical analysis identified secondary metabolites such as sterols, triterpenes, flavonoids, alkaloids, saponins, glycosides, and tannins, which are known for their antimicrobial and antioxidant properties. The Kirby-Bauer test was used to assess the inhibitory effects of *Solanum melongena L.* leaf extract, normal saline solution (NSS), and chlorhexidine against *S. mutans* and *C. albicans*. Statistical analysis, including one-way ANOVA, assessed antibacterial activity at concentrations of 50% 75%, and 100%. Results showed that there is no antifungal activity for the eggplant leaf extract, chlorhexidine, or NSS against *C. albicans* as none of them showed any zone of inhibition. However, the eggplant leaf extract showed concentration-dependent antibacterial activity against *S. mutans*, with higher concentrations producing stronger inhibitory effects. Despite the effectiveness of the eggplant leaf extract, it was proven that chlorhexidine is still more effective against *S. mutans*. These findings suggest potential applications of *Solanum melongena L.* leaf extract as a natural antibacterial agent in oral care, with further studies needed to improve its formulation for broader antimicrobial effectiveness.

Keywords: *Solanum melongena L.*, *Candida albicans*, *Streptococcus mutans*

I. INTRODUCTION

The oral cavity is a complex, non-sterile environment that supports a diverse community of microorganisms, including over 700 species of bacteria, fungi, viruses, and protozoa (Libretext Biology, 2016). For a pathogen to be harmful enough to cause carious lesions, it needs several factors: host, cariogenic biofilm, time, and fermentable carbohydrates. *Streptococcus mutans* is a primary bacterial pathogen which is well known for its ability to adhere to tooth surfaces, produce acid, and contribute to the formation of carious lesions (Pitts et.al, 2017; Forssten et al, 2010). Approximately 60–90% of the global population is affected by *Streptococcus mutans*, the primary infectious agent of dental caries (Pitts et al., 2017). Other

oral pathogen like *Candida albicans* can also inhabit the oral cavity which can cause oral infections especially in immunocompromised individuals.

On the other hand, Eggplant (*Solanum melongena L.*), a widely cultivated crop in the Philippines, primarily grown for its fruit is said to have notable pharmacological properties such as being an excellent antioxidant, antibacterial, and antifungal source (Salamatullah et al. 2021). It is also considered a broad-spectrum antibacterial that can disrupt the growth of gram-positive and gram-negative bacteria. (Santana-Gálvez et al., 2017; Ullah et al., 2020). Another study made by Khoroushi, Khorasgani & Azam Aliasghari (2017) proved that using eggplant peel effectively combats bacteria such as the three strains of streptococcus: *S. mutans*, *S. sanguinis*, and *S. Sobinus*. Eggplant peel extract is also proven effective against *Candida albicans* in a study made by Febriza et.al. (2021) However, these are mostly concentrated in the fruit rather than the leaves. There are several studies that showed the phytochemical analysis of eggplants in which it contains secondary metabolites. These secondary metabolites are solely responsible for the pharmacological activities of the eggplant which proves its potential to contain antifungal and antibacterial properties. (Solanke and Tawar, 2019)

Research on the antibacterial and antifungal properties of *Solanum melongena L. leaf* extracts are still limited in the Philippines and globally, often focusing on different dependent variables. Most existing literature emphasizes the antimicrobial properties of the peel, with only a few studies highlighting the effectiveness of the leaf extract against certain microorganisms, such as *Staphylococcus aureus*. This study aims to evaluate the efficacy of *Solanum melongena L. leaf* extract against selected pathogens, specifically *Streptococcus mutans* and *Candida albicans*.

To assess the sensitivity of the *Streptococcus mutans* and *Candida albicans* to the leaf extract, the researchers will use the Kirby Bauer Disk Diffusion Method. The zone of inhibition determined the bacterium's sensitivity to the eggplant leaf extract as an antibacterial agent to *Streptococcus mutans*. In that same test, fungal sensitivity to *Solanum melongena L.* (Eggplant) leaf extract was also evaluated to determine the susceptibility of *Candida albicans* to eggplant leaf extract as an effective antifungal. Normal Saline Solution acted as the negative control and Chlorhexidine acted as the positive control for the testing *Streptococcus mutans* and both solution was used as negative control for *Candida albicans*. These controls were used to evaluate the efficacy of *Solanum melongena L.* (Eggplant) leaf extract.

I. LITERATURE REVIEW

In the Philippines, eggplant fruit is commonly used as an ingredient in Filipino dishes which is accessible and affordable. As one of the common products found in the local markets, it has been recorded that during the third quarter of 2022, the production of eggplant expanded to 38.73 thousand metric tons, which is higher by two-point three percent than the 2021 production. Although most regions produce eggplant, Region IV-CALABARZON is the country's leading producer of eggplant (Philippine Statistics Authority, 2022). Lester and

Hasan also report that *Solanum melongena L.* (Eggplant) is commonly cultivated and consumed globally.

Eggplants are known for their benefits in nutrition, as they are rich in antioxidants, fiber, and water. Moreover, it is also a rich source of polyphenol compounds (Salamatullah et al., 2021), primarily seen in plant food that gives nutrition and protection to the body. (Petre, 2019).

The study found that eggplants are rich in secondary metabolites. Secondary metabolites are phytochemicals that frequently aid a plant's defenses against various conditions but are not necessary for the plant's essential functions. These secondary metabolites are mainly responsible for the eggplant's pharmaceutical activities. A study found that the leaves of the eggplant have four predominant characteristics: a high level of phenolic compounds and o-diphenols, flavonols, and tannins content found in mature leaves (Bouhajib et al., 2022). In addition to those findings, a phytochemical analysis from the Gborie (2021) study revealed that *Solanum melongena L.* leaves contain secondary metabolites such as saponins, flavonoids, and tannins, respectively terpenoids, phenolic compounds, cardiac glycoside, carbohydrates, and anthraquinone.

Moreover, while existing research has confirmed that secondary metabolites are present in eggplant leaf extract, the researcher proceeded with phytochemical analysis due to the specific variety of eggplant used. Although other researchers have studied the same species, *Solanum melongena L.*, the variety differs in this case wherein researchers used Calixto X1 variety. To verify the presence of secondary metabolites, the researcher conducted this analysis. A study by Diab et al. (2011) shows that eggplant peduncles can inhibit inflammation and the growth of pathogens. These are supported by a study on Eggplant leaves which showed that it contains anthocyanins and chlorogenic acid, which stop bacteria from growing and are a great source of antioxidants. Another study also proved that due to the tannin concentration, tooth decay could be prevented, as well as erosion and cavities— (University of Kansas Health System, (nd); Hertel, 2017).

The antimicrobial activities of *Solanum melongena L.* leaf were tested in the study made by AL-Janabi & Al-Rubeey (2012), wherein crude extracts of the different parts of the eggplants were tested against seven pathogenic microorganisms, which are two strains of fungi (dermatophytes) and five strains of bacteria. The study proved that the crude extracts had varying potential effects against the seven pathogenic microorganisms.

Therefore, before undergoing the phytochemical and Kirby-Bauer disk diffusion susceptibility test, the eggplant leaf extract is prepared by drying it at room temperature for 14 days; once dried, the researcher pulverized it and underwent a phytochemical test. The eggplant leaves have a phenols component of 2.39% and its known as a disinfectant agent; flavonoids with 16.18%, which is usually seen in plants that are anti-inflammatory, anti-viral and antioxidant (Ullah et al., 2020); saponin with 14.20% which is good for our blood by reducing the lipids and lower cholesterol levels also lower the risk of having cancer (Shi et al., 2004); Alkaloids with 9.53% which acts as antibacterial and anti-inflammatory (Kurek, 2019);

terpenoids with 2.34% that acts as antimicrobial, antifungal, antiparasitic, anti-viral, anti-allergenic, antispasmodic, antihyperglycemic, anti-inflammatory, and immunomodulatory properties (Thoppil & Bishayee, 2011).

For the antifungal activities of eggplant, a study made by Febriza et al. (2021) used eggplant peel extract to inhibit common oral fungi, which are *Candida albicans*, proved that flavonoids, tannins and saponins found in the eggplant peel extract are responsible for the antifungal properties of *Solanum melongena L.* Flavonoids destroy cell walls, degrade proteins and alter the lipid later as part of their mechanism of action. Tannin membranes prevent the manufacture of chitin, a compound that fungi need to build fungus cell walls. The actions of saponin as a polar surfactant reduce the surface tension of the sterol membrane from the cell wall of *Candida albicans*, which interferes with the membrane permeability and causes the entry of materials or chemicals that must be removed, which finally causes the cell to expand and lyse.

To maintain the antibacterial properties of eggplant (*Solanum melongena L.*) leaves, various preservation techniques can be utilized. Research suggests that drying methods such as microwave drying at 600 W and oven drying at 70°C effectively retain essential bioactive compounds, including phenolics and anthocyanins (BMC Plant Biology, 2025). Additionally, microwave treatment has been shown to enhance the antimicrobial properties of eggplant fruit, indicating its potential use for preserving similar properties in the leaves (MDPI, 2021). Another effective method involves ultrasound-assisted extraction using 80% ethanol, which helps sustain the antibacterial activity of bioactive compounds over time. These approaches can contribute to the prolonged medicinal and food-related applications of eggplant leaves (Salamatullah, et.al, 2021 and Rad, et.al, 2025).

II. MATERIALS AND METHODS

Research Design: The researchers employed a quantitative research methodology to investigate the efficacy of eggplant (*Solanum melongena L.*) leaves as antimicrobial and antifungal agents against selected pathogens. The study primarily focused on observing the microorganisms and assessing the impact of *Solanum melongena L.* leaf extract on their growth and viability. This research adopts a pure experimental design, wherein two specific pathogens, cultured in the laboratory, are selected for analysis. Through this quantitative approach, the researchers aim to demonstrate the effects of *Solanum melongena L.* leaf extract on both microbes and fungi. Additionally, a causal-comparative analysis is conducted to evaluate the effectiveness of the eggplant leaf extract across varying concentration gradients.

Tools and Instruments: In this study, the researchers employed statistical tools and analysis methods to analyze the data and draw conclusions. The researchers used extraction procedures, phytochemical analysis, and susceptibility testing to conclude that eggplant leaf extract has antibacterial and antifungal properties. The extraction procedure was performed to enable phytochemical analysis and susceptibility testing. This procedure was necessary to obtain a concentrated quantity of eggplant leaf extract. Phytochemical analysis was conducted to check for the presence of secondary metabolites in the eggplant leaf extract. These secondary

metabolites help the researchers descriptively define the effectiveness of the eggplant leaf extract.

Procedures: The research followed a structured experimental design to evaluate the antibacterial and antifungal activity of *Solanum melongena* L. (eggplant) leaf extract on *Streptococcus mutans* and *Candida albicans*. The study began with the selection and collection of 2000 grams of fresh eggplant leaves from Cavite and Laguna on June 23, 2024, ensuring the leaves were free of defects. The collected samples were delivered to the Department of Science and Technology (DOST) for extraction. The extraction process, conducted from June 24 to July 4, 2024, involved drying the leaves to reduce moisture content, grinding them into fine particles, and soaking them in 6 liters of solvent at 60°C for 30 minutes. The mixture was macerated for 48 hours with occasional stirring. The solution was then filtered and concentrated using a water bath at 60°C, yielding 82.2 grams of semi-solid crude extract. The extract was stored in amber bottles at 2–4°C.

On July 5, 2024, the extract was diluted into three concentrations: 100%, 75%, and 50%, using sterilized distilled water. The diluted samples were properly disinfected using a 100 ppm chlorine solution and transported to DOST and the University of the Philippines Los Baños for microbiological testing. For antifungal testing, *Candida albicans* was cultured in Tryptic Soy Broth and tested using the disc diffusion method. Discs containing various extract concentrations, as well as saline solution (NSS) and chlorhexidine as controls, were placed on the fungal culture and incubated for 24 hours at 25°C starting on July 9, 2024.

For antibacterial testing, a Kirby-Bauer Disk Diffusion Test was conducted on *Streptococcus mutans* beginning August 12, 2024. The bacteria were inoculated on Sabouraud Dextrose Agar (SDA) and incubated for 24 hours at 32°C. Paper discs infused with 50%, 75%, and 100% extract concentrations were used along with NSS (negative control) and 0.12% chlorhexidine (positive control). Zones of inhibition were measured in millimeters using calipers, with each test repeated in triplicate to ensure accuracy.

Phytochemical analysis of the extract was carried out on July 24, 2024, at the DOST Standard and Testing Division to confirm the presence of secondary metabolites such as flavonoids, alkaloids, tannins, glycosides, steroids, and terpenoids. Each metabolite was tested using standard chemical procedures like the Liebermann-Burchard test, Froth test, Shinoda's test, Mayer's reagent test, and Ferric Chloride test, among others. These results were used to support the extract's potential bioactivity.

In summary, the research proceeded in clearly defined stages—leaf collection, extraction, dilution, phytochemical testing, susceptibility testing against two microorganisms, and data analysis, spanning from late June to mid-August 2024, ensuring rigorous control and comparison of variables for valid scientific conclusions.

Analysis Techniques: The collected data in this study were processed using quantitative statistical methods to evaluate the antibacterial and antifungal effectiveness of *Solanum melongena* L. (eggplant) leaf extract. The primary metric used was the zone of inhibition,

measured in millimeters using a caliper, to assess the microbial susceptibility of *Streptococcus mutans* and *Candida albicans* to varying concentrations of the leaf extract (50%, 75%, and 100%), compared against controls—Normal Saline Solution (NSS) and 0.12% Chlorhexidine. Each test was performed in triplicate to ensure accuracy and reliability of the results. The researchers calculated the mean and standard deviation for each group to summarize the data.

For inferential statistics, the researchers employed Levene's Test to check the homogeneity of variances and the Shapiro-Wilk Test to verify the normal distribution of the data. These tests were prerequisites to determine the appropriateness of applying One-Way Analysis of Variance (ANOVA), which was used to assess whether there were statistically significant differences between the means of inhibition zones among the various concentrations and control groups. If the ANOVA indicated a significant difference, post-hoc analysis was conducted to identify which specific groups differed from each other. All statistical computations and analyses were processed using SPSS (Statistical Package for the Social Sciences) software to ensure robust and accurate data interpretation. These methods provided the researchers with a rigorous approach to evaluating the antimicrobial properties of the eggplant leaf extract, establishing both the significance and effectiveness of its potential application in oral health care.

III. RESULTS AND DISCUSSION

This chapter presents the results and interpretation of the data obtained from the antibacterial and antifungal activity tests of *Solanum melongena L.* (eggplant leaf extract) against *Streptococcus Mutans* and *Candida albicans*. The Kirby-Bauer disk diffusion test, also known as the susceptibility test, was used to obtain the values in which the data are presented in tabular form to provide a clear and comprehensive analysis in response to the study's objectives.

Table 1. Phytochemical analysis of *Solanum melongena* leaf: test parameter, results and test method

Test Parameter	Results	Test Method
Sterols	+	Lieberman- Burchard Test
Triterpines	+	Lieberman- Burchard Test
Flavanoids	+	Shinoda Test
Alkaloids	+	Mayer's Test
Saponin	+	Froth Test
Glycosides	+	Fehling's Test
Tannins	+	Ferric Chloride Test

The table presents the results, and the test methods used to identify the presence of these secondary metabolites including sterols, triterpenes, flavonoids, alkaloids, saponins, glycosides, and tannins. The results of the phytochemical analysis show a positive response, indicating the presence of triterpenes, flavonoids, alkaloids, saponins, glycosides, and tannins in the eggplant leaf extract. The results of the phytochemical analysis indicate that the secondary metabolites—alkaloids, saponins, and tannins—are present, however at a weak level (+). Furthermore, a strong presence (+++) of these secondary metabolites in eggplant leaf extract suggests its potential as an effective antibacterial and antifungal agent.

Table 2. Results of the *Solanum melongena* L. leaf extract in three different concentrations against *S. Mutans* using Kirby Bauer Test

Test Conducted	Samples	Zones of Inhibition	Average zone of Average Inhibition (mm)
Antimicrobial assay against <i>S. Mutans</i> BIOTECH 10231	50%	10.64	10.390
		10.66	
		10.56	
		11.20	
	75%	11.54	11.44
		11.59	
		11.26	
		12.90	
	100%	13.55	13.428
		14.83	
		12.24	
		14.26	

The table shows the three (3) sample concentrations (50%, 75%, and 100%) that were tested against *S. mutans* using the kirby bauer test. The table contains the resulting zones of inhibition per trial and the computed average zone of inhibition.

A 50% concentration of eggplant leaf extract against *Streptococcus mutans* produced inhibition zones of 10.64 mm on the first disk, 10.66 mm on the second disk, 10.56 mm on the third disk, 11.20 mm on the fourth disk, and 8.80 mm on the fifth disk, with an average inhibition zone of 10.39 mm. At a 75% concentration of eggplant leaf extract against *S. mutans*, inhibition zones were observed as follows: 11.54 mm on the first disk, 11.59 mm on the second disk, 11.26 mm on the third disk, and 12.90 mm on the fourth disk, resulting in an average inhibition zone of 11.44 mm. These results indicate that *S. mutans* is sensitive to eggplant leaf extract, with the 75% concentration demonstrating greater efficacy compared to the 50% concentration, as reflected by the larger inhibition zones. A 100% concentration of eggplant leaf extract demonstrates a stronger antibacterial effect against *Streptococcus mutans*. Inhibition zones of 13.55 mm were observed on the first disk, 14.83 mm on the second disk,

12.24 mm on the third disk, 14.26 mm on the fourth disk, and 12.26 mm on the fifth disk, with an average inhibition zone of 13.43 mm for the pure extract. These findings suggest that the antibacterial effect of the 100% concentration is stronger compared to the 75% and 50% concentrations.

Table 3. Results of the *Solanum melongena* L. leaf extract in three different concentrations against *Candida albicans* using Kirby Bauer Test.

Concentration	Replicate	Replicate 2	Replicate 3	total mean of zone of inhibition (mm)	Reactivity	Inhibitory activity	Verbal Interpretation
	1						
50% Eggplant Extract	0	0	0	0	0	(-)	No antifungal activity
75% Eggplant Extract	0	0	0	0	0	(-)	No antifungal activity
100% Eggplant Extract	0	0	0	0	0	(-)	No antifungal activity
Clotrimazole (positive control)	16.57	16.04	16.1	16.24	3	Positive (+++)	Higher antifungal activity
Normal Saline Solution (NSS)	0	0	0	0	0	(-)	No antifungal activity
Chlorhexidine	0	0	0	0	0	(-)	No antifungal activity

The table shows the three (3) sample concentrations (50%, 75%, and 100%) that were tested against *Candida albicans* using the kirby bauer test. The table contains the resulting zones of inhibition per trial, computed average zone of inhibition, reactivity, and inhibitory activity.

Reactivity Rating:

- 0- None (No detectable zone around or under specimen)
- 1- Slight (Some malformed or degenerated cells under the specimen)
- 2- Mild (zone limited under the specimen)
- 3-Moderate (zone extends 5mm to 10mm beyond specimen)
- 4-Severe (zone extends greater than 10 mm beyond specimen)

Inhibitory Activity Rating: (+++) complete; (++) partial; (+) slight, and (-) negative

Three (3) concentrations of eggplant leaf extract (100%, 75%, 50%) were tested against *Candida albicans*. The efficacy of eggplant leaf extract against *Candida albicans* is negligible. At a 50% concentration, no inhibition zone (0 mm) was observed in the triplicate plates, indicating a non-reactive rating with no detectable zone around the specimen. Similarly, at a 75% concentration, no inhibition zone (0 mm) was observed in the triplicate plates, yielding a 0 and negative inhibitory activity rating. Furthermore, at a 100% concentration, no inhibition zone (0 mm) was observed in the triplicate plates, with a 0 and negative inhibitory activity rating. Moreover, Sterile water and Chlorhexidine also showed no detectable zone of inhibition (0.00 mm) therefore there is no inhibitory activity present. Out of the two (2) added positive and negative control, only clotrimazole showed a significant zone of inhibition across three replicates with a mean of 16.24 mm.

IV. CONCLUSION

This study aimed to evaluate the antibacterial and antifungal activities of *Solanum melongena* L. (Eggplant) leaf extract against the oral pathogens: *Streptococcus mutans* and *Candida albicans*. Phytochemical analysis confirmed the presence of several secondary metabolites, including sterols, triterpenes, flavonoids, alkaloids, saponins, glycosides, and tannins—compounds known for their antimicrobial and antioxidant properties. Using the Kirby-Bauer test, the study assessed the inhibitory effects of *Solanum melongena* L. leaf extract, normal saline solution (NSS), and chlorhexidine against *S. mutans* and *C. albicans*.

The findings have proven that *Solanum melongena* L. leaf extract had no antifungal activity against *Candida albicans*, with no zone of inhibition observed in the triplicate plates. This result was consistent for both the normal saline solution (NSS) and chlorhexidine, indicating no inhibitory effect on *C. albicans* in this experimental setup.

In contrast, *Solanum melongena* L. leaf extract showed effectiveness against *Streptococcus mutans*. Concentrations have been observed and there is no significant difference in the 50% and 75% concentration as it had the same effect. However, the comparison between 75% and 100% extract concentrations revealed a significant increase in the antibacterial activity at the higher concentration, suggesting that the increase in concentration enhances the inhibitory effect against *S. mutans*. However, while effective, the leaf extract was less potent than chlorhexidine. Chlorhexidine has exhibited a much higher

zone of inhibition which proves its effectiveness as the gold standard for antibacterial mouthwashes. On the other hand, normal saline solution (NSS) displayed no antibacterial effect as there is no zone of inhibition detected.

These findings highlight the potential of *Solanum melongena* L. leaf extract as a natural antibacterial agent, particularly in oral care products like mouthwashes or toothpaste. Given its milder effect relative to chlorhexidine, it may be best suited for mild or moderate cases or as a complementary, natural alternative with fewer side effects. However, its lack of antifungal activity against *C. albicans* highlights a limitation, suggesting that the leaf extract would require supplementation with other antifungal agents to address a broader spectrum of oral pathogens effectively. Further research could explore optimizing the concentration and combining *Solanum melongena* L. leaf extract with other bioactive compounds to enhance its efficacy against *Candida albicans* or other oral pathogens, offering new possibilities for plant-based oral care solutions.

AUTHORS' CONTRIBUTIONS

Milger Joy C. Arquiza served as the group leader and oversaw the overall coordination and execution of the research. Chapters 1 and 2 were collaboratively written by Katrina Joyce H. Abacan, Joana Patricia I. Lapis, Milger Joy C. Arquiza, and Trizia Marie E. Cameros, focusing on the background, literature review, and conceptual framework. Chapters 3 to 5, which covered methodology, results, and conclusions, were primarily written by Milger Joy C. Arquiza and Trizia Marie E. Cameros. Final editing, formatting, and corrections were reviewed and refined under the guidance of Dr. Carmela Elazegui. All authors actively participated in data collection, analysis, and revisions, and approved the final version of the manuscript.

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