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Antibacterial Efficacy of Mangiferin in Mango (*Mangifera indica*) Peel Extract Against *Staphylococcus aureus*

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Abstract

This study examines the antibacterial activity of the mango (*Mangifera indica*) peel extract, focusing on its key bioactive compound mangiferin against *Staphylococcus aureus*. It is in an attempt to examine its effectiveness as a natural alternative to conventional antibiotics. The procedure used to find antibacterial activity of mango peel extract was agar well diffusion technique which compared different inhibition zone of different concentrations (50% and 100%) and positive (Cefoxitin) and negative (distilled water) controls. Results showed that the positive control exhibited the largest inhibition zone (27.0 mm), while the negative control showed no inhibition (0.0 mm). The 100% extract of mango peel yielded a mean inhibition zone of 18.0 mm, indicating a strong antibacterial potential, which is considered as high, and the 50% extract of mango peel yielded a moderate effect of 13.7 mm inhibition zone. Using One-Way ANOVA ($F=59.895$, $p=0.000$) proved that there are significant differences between the treatments. The 100% and 50% concentrations both showed a significant difference to the negative control ($p=0.000$) as shown by a post hoc analysis. Although, the activity of the 100% concentration was statistically significant compared with the positive control ($p=0.002$), the difference between the 100% and 50% concentration was not statistically significant ($p=0.068$). The trend shows a dose-dependent effect. This study implies that mango peel extract, due to the bioactive compounds such as mangiferin, especially at a higher concentration, has a great potential to be considered as a natural, economical and sustainable alternative against *S. aureus*.

Keywords: *Mangifera indica, Antibacterial activity, Staphylococcus aureus, Inhibition zone, Gram-positive bacterium*

1.Introduction

Staphylococcus aureus is a gram-positive bacterium commonly found on the skin and nose. These pathogens are known organisms that cause common infections causing high mortality (Howden et al., 2023). *Staphylococcus aureus* is a prevalent type of staphylococcal bacteria and one of the most severe pathogens (Abdallah 2024). Today, people overlook the harm of infections in an open wound, which causes an increase in individuals affected by *S. aureus.* Due to this, approximately 30% of the human population are infected with *S. aureus* (Tong et al., 2015).

Mangiferin is a xanthone that is present in various parts of the mango plant, such as the peels, stalks, leaves, barks, and kernel (Imran et al., 2017). It is a bioactive ingredient that contains potent pharmacological effects. (Du et al., 2018). Limited studies have focused on the antibacterial activity of mangiferin using mango peels specifically against *S. aureus*.

In this study, the researcher will establish the antibacterial activity of mangiferin in mango peels against *Staphylococcus aureus* in vitro. It will also use mango peels as the source of mangiferin to influence the sustainable usage of natural resources as an effective alternative antibacterial. The findings can be used in making cost-effective antibiotics that could help address the growing problem of antibiotic resistance.

2.Review of Related Literature

This research delves into the properties of mangiferin and where it is extracted from, how *Staphylococcus aureus* originated and how it affects the healthcare and community settings, phytochemical screening of *Mangifera indica*, how mangiferin combats *S. aureus* with its antibacterial properties, and the mechanism of action. It will also investigate how a purified extract of mangiferin affects *S. aureus*. The research also evaluates *S. aureus*' broader implications for human health.

Mechanism of Action

There are many pointers to find the mechanism of antibacterial action of mangiferin this research goes in depth to explain key pointers that underlay the pointers. Mangiferin breaks up the structure and integrity of the wall of the bacterial cell and thereby plays an important role in the survival of the bacterium (Emeka et al., 2023). *S. aureus* forms a biofilm in order to retard the diffusion of antimicrobial drugs. (Idrees et al., 2023). Mangiferin will fight the bacterial cells of *S. aureus*, namely *S. aureus* to eliminate or minimize its development. It interferes its metabolic process causing the infection of *S. aureus* to slow down or stop ultimately.

Staphylococcus aureus

Staphylococcus aureus is a gram-positive bacterium that is normally present on the skin and nasal passages, but when it enters the body, it may cause serious infections (Cheung et al., 2021). It has been isolated by Ogston in 1880 and was named by Rosenbach in 1884, its medical importance was further widened by the emergence of Methicillin-Resistant *S. aureus* in 1961 (Feng et al., 2008). It is known to cause major infections like blood stream infections, pneumonia, surgical site infections, skin and soft tissue infections which have increased health risks to the public health (David & Daum, 2017).

Mangiferin in *Mangifera indica*

Mangiferin is a bioactive compound that occurs in mango (*Mangifera indica*), and in other species of plants in the family Anacardiaceae and Gentianaceae (Gold-Smith et al., 2016). This research will use mangoes

(*Mangifera indica*) as source for the extraction of mangiferin. This research will use ethanol as a base solvent for the extraction of a higher concentration of mangiferin. Mangiferin has several therapeutic activities like antibacterial, antiviral, antidiabetic, antioxidant, and others (Duet et al., 2018). Mangiferin-aqueous extracts are easy to obtain because because they are water-soluble, ethanol provide a higher purity of mangiferin (Castro-Munoz et al., 2024).

Antibacterial Activity Against *Staphylococcus aureus*

Mangiferin has been shown to increase the activities of the used antibiotics on bacteria. For instance, the 4 mg/disc mangiferin was demonstrated to present synergistic activity in combination with other antibiotics against *S. aureus* (Mazlan et al., 2019). Pure extraction of mangiferin was found to have high antimicrobial activity with the MIC as low as 1.95 micrograms/ml against *S. aureus* and as such, it may be a novel drug of tomorrow (Yehia et al., 2023). *M. Indica* bark extract demonstrated an excellent potential of enhancing the effectiveness of conventional antibiotics (Ekamgue et al., 2023). With the growing rate of population of mankind, the infections of *S. aureus* are continuously increasing. The use of mangiferin in the preparation of antibiotics against *S. aureus* will greatly decrease the number of people suffering from it.

Phytochemical screening of Mangifera indica

Knowing the phytochemicals present in extracting a mango peel extract is vital in detecting compounds which are responsible for the plant's effects such as its antibacterial property. Phenolics, alkaloids, saponins, glycosides, terpenes, and tannins are major phytochemicals found in *Mangifera indica,* with this, mangiferin is a major compound found in it (Kumar et al., 2021). Using mangiferin as a main contributor in making a peel extract from mangoes is essential.

3.Theoretical Framework

The scientific theory stated by the study is the theory of natural selection which proposes that bacteria will develop resistance to antibiotics, the bacteria with advantageous traits within the population are likely to reproduce and survive. When bacteria are under selective pressure of an antibiotic, the bacteria with resistance will survive the treatment and will reproduce, leading to a greater population and over time, the resistance trait can become more prevalent in the bacteria population.

This theory supports the urgency in discovering alternative antibiotics. The use of mangiferin in making a mango peel extract as an alternative to combat *S. aureus* clarifies this. Inhibiting biofilm formation, which is a key virulence factor for *S. aureus* in chronic infections, has been shown for mangiferin. By affecting both planktonic bacteria and biofilms, mangiferin offers quite an attractive natural alternative to conventional antibiotics with a lower risk of developing antibiotic resistance. Future studies must investigate the possible synergy with other antimicrobial agents to utilize its full therapeutic potential.

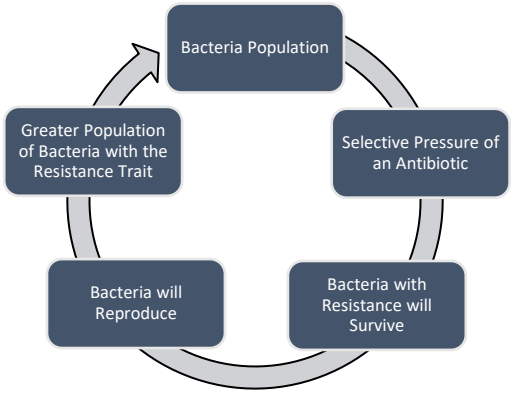


Figure 1. Theory of Natural Selection

4.Hypotheses and Objectives

Hypotheses

1. If a purified mango peel extract is applied on a culture plate of *Staphylococcus aureus*, then it will inhibit the growth of *S. aureus*.
2. If we put mango peel extract on *S. aureus*, then it will create an inhibition zone where no bacteria can grow.
3. If we compare the antibacterial activity of the mango peel extract to the positive control, then there will be a statistically significant difference in its inhibition.

Objectives

1. To determine the antimicrobial property of mangiferin obtained from mango peels (*Mangifera indica*) against *Staphylococcus aureus* in vitro.
2. To measure the antibacterial activity of mango peel extract by analyzing its inhibition zone diameters.
3. To compare the antibacterial activity of the mango peel extract with that of a negative control and positive control.

5.Methodology

5.1 Methods

This study utilized mango peels regarded as waste as its source material. The mango peels were authenticated by a plant expert/botanist at the Provincial Agriculture Office. The peels were thoroughly washed, sun-dried, and ground using a mechanical grinder at Tagum Doctors College Inc. (TDCI) Microbiology Laboratory.

The laboratory materials needed were supplied by TDCI Microbiology Laboratory and included sterilized Petri plates, agar (MHA, MSA, NA) plates, nutrient broth test tubes, micropipettes, beakers, 100% pure ethanol, distilled water, sterile cotton swabs, graduated cylinders and sterile filter paper discs measuring 6 mm in diameter. A pure culture of *Staphylococcus aureus* was purchased at the Tagum Doctors Hospital Laboratory Department with a duly certified result by a licensed medical technologist. Standard antibiotic disc (Cefoxitin) was used as positive control for *S. aureus* and discs impregnated with distilled water were used as negative controls.



Figure 2. Pure culture of *Staphylococcus aureus*

Disc diffusion assays were conducted in a microorganism incubator maintained at 38.0°C and zones of inhibition were measured with a calibrated digital caliper to ensure accurate recording of antibacterial effects.

This study underwent seven phases: Preparation of Materials, Sterilization, Preparation of Bacterial Culture, Solvent Extraction, Application and Antibacterial Testing, Measurement and Data Collection, and Waste Disposal. Beforehand, the researcher adhered to safety ethics provided by the International Science and Engineering Fair.

5.2 Subject of the Study

The population of bacteria used was *Staphylococcus aureus.* The sampling technique was Purposive Sampling.

5.3 Phases

Phase 1 – Preparation of Materials

Unripe mangoes (*Mangifera indica*) specifically Carabao mangoes were bought at the Tagum City Fruits and Vegetables Building located at Santa Cruz Ave, Tagum City. The mangoes were authenticated by a qualified botanist or plant expert from the Provincial Agriculture Office (PAGRO), and a confirmatory certificate was obtained. The mangoes were washed thoroughly with tap water to remove any surface dirt, debris and contaminants. The peels were then peeled and patted dry using a clean cloth. The peels were then sun-dried for 2 days until dehydrated. Once dried, the peels were ground into fine powder using a mechanical grinder.



Figure *3*. Buying mangoes



Figure 4. Washing and peeling the mangoes

Phase 2 – Sterilization

All glassware, equipment and materials used in the study were sterilized in an autoclave at 121°C for 15–20 minutes before use to prevent contamination. The laboratory workspace was disinfected with absolute ethanol and a Lysol disinfectant spray prior to and after each experimental procedure. All bacterial handling was performed under aseptic conditions within a sterile environment.



Figure 6. Autoclaving equipment

Phase 3 – Preparation of Bacterial Culture

Various culture media were prepared manually following standard protocols per type of media, namely, Mueller-Hinton Agar (MHA), Nutrient Agar (NA), and Mannitol Salt Agar (MSA) culture plates. A pure culture of *Staphylococcus aureus* was obtained from the Tagum Doctors Hospital Laboratory. Strains were cultured in nutrient broths at 38°C for 18–24 hours and standardized according to the 0.5 McFarland turbidity standard.

In the TDCI Microbiology Laboratory, Mueller-Hinton Agar (MHA), Nutrient Agar (NA), and Mannitol Salt Agar (MSA) plates were uniformly inoculated with the bacterial suspensions using sterile swabs to ensure even distribution.

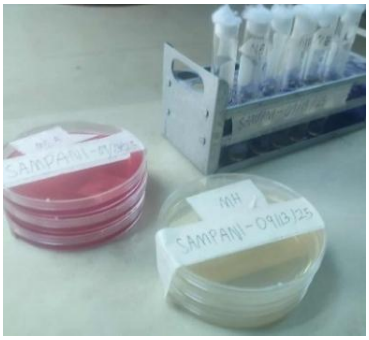


Figure 7. *Preparation of different culture media*



Figure 8. Isolation of pure cultures of *S. aureus* into sub-cultures



Figure 9. Standardization of McFarland solution

Phase 4 – Solvent Extraction

For the extraction process, 100 grams of powdered mango peels were soaked in 1L of 100% pure ethanol for 24 hours. The mixture was filtered using cheesecloth followed by Whatman filter paper. The filtrate was concentrated using a rotary evaporator under reduced pressure and controlled temperature to remove excess ethanol, resulting in a crude ethanolic extract of mango peels.



Figure 10. Weighing of mango peels



Figure 11. Soaking of powdered mango peels in 1L of ethanol

Phase 5 – Application and Antibacterial Testing

To prepare the test concentrations, the crude ethanolic extract was diluted with ethanol to create 2 concentrations: 50%, and 100%. The following formulations were prepared:

- 100% concentration – pure crude ethanolic extract (undiluted)
- 50% concentration – 12.5 mL crude extract mixed with 12.5 mL ethanol

Sterile filter paper discs were impregnated with 10 µL of each concentration and air-dried. These discs were then placed onto agar plates previously inoculated with *S. aureus*. For controls, Cefoxitin served as the positive effect for *S. aureus*, and distilled water served as the negative control. All plates were incubated at 38°C for 18–24 hours.

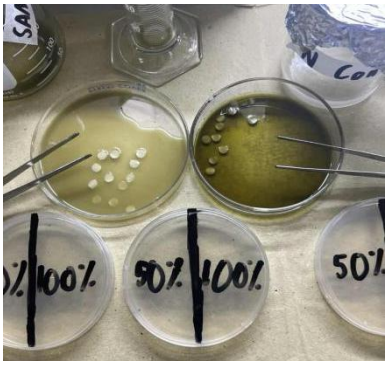


Figure 12. Preparation of ethanol plant extract concentrations



Figure 13. Planting paper discs impregnated with mango peel extract into cultures of *S. aureus*

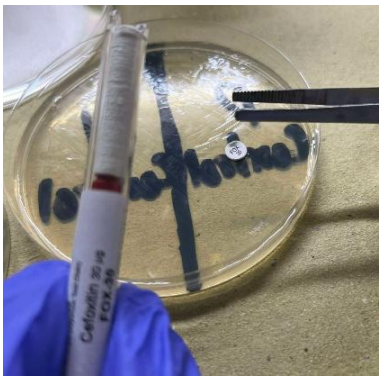


Figure 14. Planting positive (Cefoxitin) and negative (distilled water) controls into a culture of *S. aureus*

Phase 6 – Measurement and Data Collection

After incubation, the antibacterial activity of each extract concentration was evaluated by measuring the zones of inhibition around the discs. The diameters of the clear zones were measured in millimeters using a transparent ruler. All results were recorded and tabulated for statistical analysis. Comparisons between the extract concentrations and control treatments were made to determine the relative antibacterial efficacy of the mango peel extract.

Phase 7 – Waste Disposal

Upon completion of the experiment, all used materials—including culture plates, swabs, and filter paper discs—were autoclaved prior to disposal. Residual solvents and plant extracts were discarded following institutional biosafety and environmental safety guidelines. Reusable glassware and equipment were thoroughly cleaned, sterilized, and properly stored. These procedures ensured laboratory safety, prevented contamination, and complied with environmental regulations.

6.Data Analysis

The main objective for doing the data analysis will be to test the efficacy of mango peel extract against *Staphylococcus aureus*. This analysis is important for understanding the ability of the extract to play the role of an alternative antibiotic. The data collected during the data collection will be analyzed using statistics.

6.1 Analysis of Antimicrobial Activity

Inhibition zone diameters will be measured to check the efficacy of mango peel extract against *Staphylococcus aureus*. The dimensions of the inhibition zone are going to be in millimeters with a larger inhibition zone having a stronger antibacterial activity.

6.2 ANOVA

To test whether there are any significant differences between the means of treatments It tests the difference between between groups and within groups and this means that the treatments have a real effect.

7.Risk Assessment

The investigation of mango (*Mangifera indica*) antimicrobial potential of mangiferin against *Staphylococcus aureus* contained a number of hazards which should be managed to ensure the safety of the researchers, authenticity of the study and ethical use of biological materials. These risks included data security, chemical hazards and biological hazards. Safety precautions were taken to eliminate any risks which might arise during the laboratory work and microbial testing. Some of the main risk factors in this study as well as safety precautions to be implemented are discussed in this section.

7.1 Biological Hazards

In this study, *Staphylococcus aureus* was being treated as a chronic pathogen. A pathogen refers to any organism or some active agent of infection capable of invading the tissue of susceptible host to cause infection or contamination. With this, the appropriate safety practices were followed to decrease the risk of infection of *S. aureus*. Therefore, biosafety measures were in place such as personal protective equipment (PPE), sterilization protocols, and containment protocols to avoid the accidental exposure or transmission.

7.2 Contamination Risks

Aseptic techniques were used and strictly adhered to to avoid contamination of bacteria cultures and other equipment used to handle these cultures.

7.3 Waste Disposal

All cultures and disposables were autoclaved before disposal.

7.4 Chemical Hazards

In the course of the extraction and analysis of mangiferin, the use of solvents and reagents that could pose as hazardous pollutants due to toxicity, flammability, and irritating properties to the skin were reported. Thus, gloves and goggles as well as safe storage practices were important to reduce exposure and maintain a safe laboratory environment.

7.5 Sample Integrity and Data Security

The precision of the microbiological and chemical analyses in the study demanded that actions be taken to implement strict controls against the possibility of loss of data, contamination of samples, or misinterpretation of results. With this type of safety measures, there was an attempt to reduce any potential risk that relates to biological or chemical hazards and safeguard the integrity and reliability of the research finding.

8.Results and Discussions

This section introduces the results of the antibacterial potential of peel extract of mango (*Mangifera indica*) against *Staphylococcus aureus*. The first part of the study was done on whether the extract can be used as a possible alternative to antibiotics by comparing the inhibition zones of the extract, positive and negative controls. Statistical analysis was done to find out whether there is a significant difference in antibacterial activity between the mango peel extract and positive and negative control. These results give an insight into the use of the extract as a natural and sustainable antibacterial agent.

8.1 Antibacterial Property

Table 1 presents the mean zones of inhibition of the various treatments against *Staphylococcus aureus*, which indicate the antibacterial effectiveness of the mango peel extract at different concentrations with the positive and negative controls. The inhibition zone (27.0 mm) was found in the positive control with a statement of high antibacterial activity which gave the confidence of the efficacy of the used standard antibiotic and also provided a suitable guideline for the antibacterial performance. This result validates the sensitivity of *S. aureus* towards the standard antibiotic and thus the reliability of the test conditions but also of the assay method.

On the other hand, the negative control was shown to have no zone of inhibition (0.0 mm) indicating a negative result confirming that the diluent or solvent used in the preparation of the extract does not have any antibacterial property by itself. This result is very important as we can be sure that the inhibitory effects observed in the mango peel treatment are only due to the bioactive constituents of the extract and not because of the medium of the experiment.

Table 1
Mean Zones of Inhibition of Various Treatments Against *S. aureus*

Treatment	Mean	SD	Remarks
Positive control	27.0	0.00	High
Negative control	0.0	0.00	Negative
50% Extract	13.7	2.52	Moderate
100% Extract	18.0	4.36	High

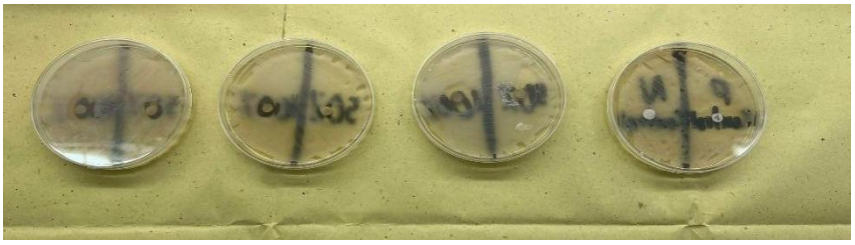


Figure 16. Zones of inhibition of Mango peel extract (varying concentrations), positive, and negative controls on *S. aureus* colonies

Among the extracts, the 100% peel mango extract showed a mean inhibition zone of 18.0 mm and this was classified as high showing a strong antibacterial potential against *Staphylococcus aureus*. This result suggests that the crude extract in full concentration has a higher concentration of active phytochemicals that are responsible for inhibiting the growth of bacteria. In contrast, the extract at 50% gave a mean inhibition zone

of 13.7 mm, which is a moderate antibacterial activity. The very distinct difference between both concentrations shows that the antibacterial activity of mango peel extract is concentration-dependent, i.e. as the concentration of the extract increases, its potential to inhibit bacterial growth is also increased.

This can be explained by the presence of the major bioactive compound mangiferin present in high amounts in the mango peel. Mangiferin, a polyphenolic xanthone glycoside, a natural component, was reported in the literature for diverse biological activities such as broad-spectrum antibacterial activity, antiviral activity, and antioxidant activity.

Its antibacterial mode of action includes several biochemical pathways: (1) disruption of bacterial cell wall and membrane integrity resulting in leakage of intracellular contents; (2) chelation of metal ions required for bacterial enzyme function; (3) production of ROS that damage bacterial DNA and proteins; and (4) inhibition of nucleic acid synthesis and metabolic enzyme activities resulting in inhibition of bacterial replication and survival. All these mechanisms together account for the observed inhibitory effect of mango peel extract against *S. aureus*.

Moreover, although the extract's performance is a bit lower than the positive control (27.0 mm), it is still important and shows that natural phytochemicals can have significant antimicrobial effects similar to those of synthetic antibiotics. The lack of inhibition in the negative control (0.0 mm) proves that the solvent by itself is not responsible for bacterial inhibition, and thus, that the activity is due to the mango peel constituents.

Consequently, the results support the antibacterial activity of mangiferin and confirm the potentiality of mango peel extract as a natural, low cost and eco-friendly alternative to traditional antibiotics. Considering the increasing worldwide concern on the antibiotic resistance, such plant-derived compounds represent a promising source for the development of new antimicrobial compounds from agricultural by-products. These results also demonstrate the importance of mango peel, which is considered as a waste product, as a bioactive resource possessing important pharmaceutical potential.

8.2 Statistical Analysis

Table 2A presents the results of the One-Way Analysis of Variance (ANOVA) conducted on the mean zones of inhibition among the different treatments against *Staphylococcus aureus*. The purpose of this analysis was to determine whether there are statistically significant differences in antibacterial activity among the treatments—namely, the positive control, negative control, 50% mango peel extract, and 100% mango peel extract.

Table 2A

One-Way Analysis of Variance on the Mean Zones of Inhibition among Treatments

Source of Variations	Sum of Squares	df	Mean Square	F	P value	Remarks
Between Groups	1138.000	3	379.333	59.895	.000	Significant
Within Groups	50.667	8	6.333			
Total	1188.667	11				

***Calculation was significant @ p <.05**

The results are as follows: F-value = 59.895 and p-value = 0.000 which is less than 0.05 level of significance. This shows there is a statistically significant difference between the mean zones of inhibition in the treatments.

In other words, at least one of the treatment groups demonstrates a level of antibacterial activity which is significantly different from other groups. The table includes the phrase "Significant" which indeed indicates the null hypothesis (all treatment means are equal) has been rejected.

However, as a collection of statistics, ANOVA can only determine that there is a significant difference somewhere, but it cannot tell you, which groups are different from one another. If one is interested in determining which treatments if any are responsible for this large effect (e.g., is the 100% mango peel extract different from the positive control; or is the 50% extract different from the negative control), then a post hoc analysis (e.g., Tukey's HSD or Duncan's multiple range test) is needed.

Post hoc test will help in a more detailed comparison of the treatments and it will help to determine which concentrations of mango peel extract have antibacterial activity similar or significantly different from that of the standard antibiotic. This step should be critical in confirming the extract's potential as a natural antibacterial agent to select the optimum concentration against *S. aureus*.

8.3 Post Hoc Multiple Mean Comparison Test

Table 2B presents the results of the Post Hoc Multiple Mean Comparison Test conducted after the One-Way ANOVA to determine which specific pairs of treatments differ significantly in their mean zones of inhibition against *Staphylococcus aureus*. Since the ANOVA results (Table 2A) revealed a significant overall difference among treatments ($p = 0.000$), this post hoc analysis was necessary to identify the exact sources of variation and clarify which treatments exhibited statistically different antibacterial effects.

Table 2B

Post Hoc Multiple Mean Comparison Test of the Mean Zones of Inhibition among Treatments

(I) Types of Treatment	(J) Types of Treatment	Mean Difference (I-J)	P value	Remarks*
Positive control	Negative control	27.00*	.000	Significant
	50%	13.33*	.000	Significant
	100%	9.00*	.002	Significant
Negative control	Positive control	-27.00*	.000	Significant
	50%	-13.67*	.000	Significant
	100%	-18.00*	.000	Significant
50%	Positive control	-13.33*	.000	Significant

	Negative control	13.67*	.000	Significant
	100%	-4.33	.068	Not Significant
100%	Positive control	-9.00*	.002	Significant
	Negative control	18.00*	.000	Significant
	50%	4.33	.068	Not Significant

***Calculation was significant @ p <.05**

The results indicate that the positive control was significantly different from all other treatments including the negative control (p = 0.000), the 50% extract (p = 0.000) and 100% extract (p = 0.002). This affirms the fact that the standard antibiotic is still the most effective antibiotic treatment, with the best antibacterial activity of all other groups.

Similarly, the negative control was significantly different from all the other treatments (p = 0.000), which reinforced the idea that the solvent or base medium had no antibacterial property and gave validity to all observed inhibition zone data in the extracts due to their bioactive compounds, especially mangiferin.

When compared extract concentrations, the difference between the 50% extract and 100% extract did not have a statistical significance (p = 0.068). This indicates that even if the mean zone of inhibition for the 100% extract was slightly larger (18.0 mm) compared to the 50% extract (13.7 mm), the difference in the antibacterial activity between the two is not statistically significant at the 0.05 level of significance. Nevertheless, the trend remains to be dose-dependent since the higher concentration always caused greater inhibition.

The 100% extract also showed a significant difference from the positive control (p = 0.002), but it is still remarkable that the inhibition zone of the mango peel extract was not very far from each other, which appears to suggest that the mango peel extract, in full concentration level, is showing a strong anti-bacterial effect and is close to the inhibition zone of the standard antibiotic.

Overall, the post hoc results confirm that the mango peel extract has a significant antibacterial activity against the negative control and that is affected by the concentration. The results support the role of mangiferin and the other phenolic compounds in the mango peel as important factors in bacterial growth inhibition. These results further confirm the conclusion that mango peel extract (especially at higher concentrations) can be a potential natural and sustainable alternative antibacterial agent against *Staphylococcus aureus*.

9.Conclusion

The findings provide conclusive evidence that mango (*Mangifera indica*) peel extract possesses significant antibacterial properties, where having a higher concentration consistently showed a strong antibacterial potential against *Staphylococcus aureus*. Results showed that a 100% concentration produced a mean inhibition zone of 18.0 mm. Whereas, the 50% concentration produced a mean inhibition zone of 13.7 mm. The clear difference between the inhibition zones of the two concentrations, suggest that the antibacterial activity of the mango (*Mangifera* indica) peel extract peel extract is concentration-dependent.

With relation to mangiferin, its antibacterial mechanism involves multiple biochemical pathways, such as, disruption of bacterial cell wall and membrane integrity and inhibition of nucleic acid synthesis and metabolic enzymes, it impairs bacterial replication and survival. These mechanisms explain the inhibitory effect of mango peel extract against *S. aureus*.

The findings verify the role of mangiferin and other phenolic compounds found in the mango peel as key contributors to bacterial growth inhibition. These results conclude that at a higher concentration, mango peel extracts can be considered as a potential natural antibacterial agent against *Staphylococcus aureus*.

10.Recommendations

The researcher suggests to focus on isolating and characterizing the other specific bioactive compounds responsible for the inhibitory effect in the mango peel extract. The researcher also suggests to compare the difference in using ripe and unripe mangoes (*Mangifera indica),* whether it will show a statistically significant difference between its inhibition zones. Furthermore, microscopic examination is highly suggested to know how the mangiferin in the mango peel extract, disrupts bacterial cell wall and membrane integrity.

To further validate the therapeutic potential of the mango peel extract, in vivo studies are recommended. Moreover, in silico studies are also recommended to predict its efficacy, and to predict its behavior. Additionally, the researcher suggests to explore different extraction methods that could enhance the bioavailability and targeted delivery of the active compounds, where it could potentially improve its antibacterial inhibition.

In conclusion, the study paves a promising step towards the development of an alternative natural antibiotic against *Staphylococcus aureus* that is effective and accessible. However, widespread work remains to disseminate these findings into clinical applications. While the potential accessibility and effectiveness is encouraging, further research is needed to overcome limitations and challenges to bring this finding closer to clinical applicability.

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Declaration of Conflicting Interests

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