Comparative Study Of Antimicrobial Activity (Antibacterial) Of *Syzygium Cumini* Seeds Extract And *Carica Papaya* Leaf Extract

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ABSTRACT
The purpose of this study is to compare the antimicrobial properties of natural extracts from both *Carica papaya* leaf and *Syzygium cumini* seeds. The extracts were tested against typical bacterial species using traditional agar diffusion methods including *Bacillus subtilis, Staphylococcus aureus, Escherichia coli*, and *Salmonella typhi*. For both extracts, the findings showed notable antibacterial action; *Syzygium cumini* showed more inhibitory zones than *Carica papaya*. Both extracts exhibited bioactive components including tannins and flavonoids in phytochemical analysis, which most certainly help to explain their antibacterial action. Using this comparative analysis, the therapeutic uses of natural plant extracts as alternative antibacterial agents are highlighted, therefore offering an understanding of their possibilities in the prevention of bacterial infections. More investigation is needed to clarify the processes behind their antibacterial properties and their possibilities in therapeutic environments.

KEYWORDS: *Antimicrobial activity, Syzygium cumini seeds, Carica papaya leaf, Antibacterial activity.*

INTRODUCTION:
The other tree, native to "the Indian subcontinent and Southeast Asia", is the *Syzygium cumini*, more famously known as Jamun or Java plum. It has come to notice for its numerous uses in medicine and continues to take part significantly in traditional medicine such as Ayurveda. Because of its possible health benefits, *Syzygium cumini* and its fruits have been under constant research: "The fruits are sweet and slightly acidic and might be eaten raw". A lower amount of research has been invested into the seeds of this plant, however. Whereas the seeds of *Syzygium cumini* are typically discarded after eating the fruit, there has been some recent interest placed into them due to the potential that they contain therapeutic properties. The bioactive compounds in these seeds abound and include tannins, flavonoids, and phenolics which are known to be antibacterial (Bukhari et al., 2021). Antioxidants play an important role in the scavenging of harmful free radicals and combating diseases related to oxidative stress, such as diabetes, heart disease, and even cancers. Besides, "traditional medicine for the treatment of diabetes" has utilized *Syzygium cumini* seeds. Laboratory analyses have shown that the extracts from the seeds may inhibit the enzyme α-amylase and other carbohydrate digestive enzymes. It is plausible that this could reduce post-meal blood glucose levels. Due to this property, they represent the ideal organisms to study and carry out research to develop natural diabetes medications. It has been demonstrated that the seeds of *Syzygium cumini* have antibacterial properties in addition to their antimicrobial characteristics. The extracts have the potential to yield natural antibacterial medicines because they have inhibitory actions against a variety of diseases (Adelakun et al., 2024).
Despite their traditional use and promising bioactivity, well-grounded scientific investigations into the antimicrobial activities of *Syzygium cumini* seeds remain scant. It hence became imperative to carry out such a study that would adequately investigate the antimicrobial activities of *Syzygium cumini* seeds by standard experimental protocols. Said differently, we have to explain the bioactive properties of this seed. The bioactive compounds present in medicinal plants represent an important resource that has been used for ages in traditional medicine. Examples include metabolites, glycosides, polyphenols, and terpenoids. All these compounds exercise varied protection functions, which include defending against a broad variety of pests and diseases. *Carica papaya* fruit contains a high level of carbohydrates, vitamins C, A and E, minerals such as magnesium, potassium, and calcium. The most common antioxidants in plant-based dishes include vitamins B, C and E, and chemicals such as carotenoid and phenolic (Ajiboye & Olawoyin, 2020).
The leaves are cooked in many tropical areas instead of the fruit, being more calorically dense ingredients. Leaves also contain high amounts of salt (16 mg), calcium (334 mg), protein (7.0 g), vitamins B and E (136 mg) and phosphorus (142 mg). It has been used to tenderise meat together with papain and some enzymes present in fruits and latex of *Carica papaya*. *Carica papaya* lipase is an immobile biocatalyst for the esterification-transesterification and other reactions of fats and oils with organic solvents present in the latex of *Carica papaya* (Vanlalveni et al., 2021). Some of the many health benefits attributed to *Carica papaya* include preventing the oxidation of cholesterol, soothing gastrointestinal problems such as nausea and morning sickness, helping with weight loss, enhancing immunity, assisting kidney healing, affecting liver cancer cells, treating dengue fever, and regularizing women's menstrual cycle. In general, extracts from the leaves of *Carica papaya* are used to guard against pests or insects. It contained several phytochemical components including carbohydrates, proteins, anthraquinones, flavonoids, saponins, cardiac glycosides, and alkaloids. Milind and

Gurditta presented a review on the nutritional and therapeutic uses of *Carica papaya*. Leaves of whole *Carica papaya* are used traditionally for medicinal purposes. The anti-bacterial, wound healing and other important therapeutic features of *Carica papaya* are discussed below (Banthia et al., 2024).

BACKGROUND OF THE STUDY:

It is the fruit of the *Syzygium cumini* seeds, native to the Indian subcontinent and Southeast Asia. Because of its many health benefits, it has taken on a position of importance within traditional medicine. The sweet and sour taste of the fruit makes it ideal for consumption either raw or in other delicious treats in a blended manner. For centuries, traditional medicinal systems like Ayurveda valued *Syzygium cumini* not only for its culinary purpose but also because it contains medicinal properties. Because of the high contents of phytochemicals in *Syzygium cumini* seeds, this plant is thought to contain therapeutic properties. The fruit is rich in various bioactive compounds including vitamins and minerals such as polyphenols, anthocyanins, and flavonoids. Those compounds might inhibit oxidative stress in cells through free radicals scavenging and are thus completely intensive with antioxidant activities. Oxidative stresses form a part of several chronic diseases, like cancer, diabetes, and heart difficulties. *Syzygium cumini* exhibits great potential as a medicinal or prophylactic measure against several illnesses because of its antioxidant features. Interest in *Syzygium cumini* has increased today for its antioxidant action and supposed antidiabetic activity (Dagne et al., 2021). Various studies have established that an action of reduction of blood sugar and prevention of hyperglycemia could be attributed to various extracts obtained from this plant, including its fruit and seeds. This could be explained through their inhibitory action against carbohydrate digestion enzymes such as α-amylase and α-glucosidase, which would lower the postprandial blood glucose levels by delaying glucose absorption. *Syzygium cumini* could act as a natural alternative to classic drugs used in diabetes since it may facilitate glucose regulation and management by several modes of action. Other than the antidiabetic effect, *Syzygium cumini* may be an effective killer of several bacterial species on account of its antimicrobial properties. The bioactive elements could inhibit the growth of certain bacteria, fungi, and viruses and thus may be used as an effective antibacterial agent. The capability of SKC to inhibit the growth of microbes could make it a potential candidate for infectious diseases and immune system treatment. Therefore, scientific investigations are warranted to validate the traditional use and anecdotal evidence of the medicinal advantages of *Syzygium cumini* and to comprehend the mechanism underlying it. Whatever the seeds of *Syzygium cumini* may contain useful compounds, they have not attained due attention from the researchers (Kaur et al., 2024).

Members of the Caricaceae family include the *Carica papaya*. The pawpaw tree is also known as tinti, pepol, chich put, fan kua, wan shou kuo, kavunagaci, kepaya, and *Carica papaya*, among other common names. Leaves, fruit, seeds, latex, and roots are the most common portions utilised. This plant is characterised as a fast-growing, upright, mostly unbranched shrub or tree that is 7-8 meters tall and has a trunk that is approximately 20 centimetres in diameter and profuse latex. Also included among the plant's reported properties are its analgesic, amebicide, antibacterial, cardiotonic, cholagogue, digestive, emenagogue, febrifuge, hypotensive, laxative, pectoral, stomachic, and vermifuge effects. It ends up all over the place, from Asia to Nigeria and beyond (Ertas Onmaz et al., 2022). The tropical fruit-bearing plant *Carica papaya* is now cultivated worldwide in tropical and subtropical climes, despite its origins in Mexico and Central America. *Carica papaya* trees are identifiable by their large, lobed leaves and melon-like fruits; in tropical climates, they may reach a height of 10 meters. There are a lot of biochemically active substances in *Carica papaya*. The digestive enzymes papain and chymopapain are two key components. The anti-arthritis properties of papain are well-documented. Soap substitutes made from *Carica papaya* leaves are said to be effective stain removers. Numerous industrial applications exist for papain, a proteolytic enzyme. It degrades proteins and acts as a rennet to coagulate milk. Papain is a medicinal agent that helps with dyspepsia and other gastrointestinal disorders; it is active throughout a broad pH range (Mahmoud et al., 2023). Its swollen tonsils have been reduced using liquid treatments. Papain is added to over 80% of American beers. It breaks down the precipitable protein fragments and leaves the beverage clear when cooled. The gumminess of natural silk may be removed using papain as well. Meat tenderisers and chewing gums make up the bulk of the U.S.'s imported papin. It is also used in the cosmetic industry to extract tuna liver oil, which finds its way into various dentifrices, shampoos, and face-lifting formulas. For use in dehairing hides before tanning and in cleating wools and silks before to colouring. The production of "rubber from heaven" also makes use of it. The culturally significant and versatile *Carica papaya* plant has several applications, including in medicine, the kitchen, and industry. Because of its high nutrient content and potential health benefits, it is widely cultivated in tropical regions across the world (Roshan et al., 2024). Traditional medicine has long been acknowledged for its ability to treat a wide range of diseases. The paradise fruit tree Native to the Americas, the *Carica papaya* plant is cultivated for its edible fruit and possible medicinal properties. *Carica papaya* trees have a long list of beneficial applications, but the leaves' potent medicinal properties have driven up their profile in recent years. The medical effects of

Carica papaya leaf extract are due in part to its bioactive components, which include essential oils, phenolic compounds, alkaloids, and flavonoids. Several studies have shown that *Carica papaya* leaf extract is efficient against a wide variety of bacteria, viruses, fungi, and other diseases. It has long been recognised that natural commodities, particularly plant extracts, contain a broad array of bioactive compounds with antibacterial properties. Medicinal herbs have a long history of usage as all-natural cures for a wide variety of illnesses. The possible antibacterial activity of several plant extracts makes them useful in the treatment of many illnesses (Shidiki & Vyas, 2022).

PURPOSE OF THE STUDY:

This study will compare the antimicrobial properties of natural extracts received from leaf extracts of *Carica papaya* and seed extracts of *Syzygium cumini*. The study is scientifically going to advocate for their traditional use in both biomedicine and environmental science, showing great potential for the development of effective therapies at low cost for a variety of illnesses. Traditional use of seeds of *Syzygium cumini* is discussed as a natural antibacterial agent. Therefore, it assesses their performance in the reduction of oxidative stress, regulating blood glucose levels, and fighting microbial infection. This present study uses different experimental methodologies to ascertain their antimicrobial efficacy and activity. Therefore, this research work is targeted at the exploitation of *Carica papaya* leaf extract for the development of effective and sustainable antimicrobial agents with dual applications in the fields of biomedicine and environmental sciences.

LITERATURE REVIEW:

The scientific name of the plant is *Syzygium cumini*, but in its native place, the plant is famous as "Jamun". The plant belongs to the Myrtaceae family. *Syzygium cumini* belongs to the Myrtaceae family, which comprises tropical evergreen trees originating from Nepal, India, Pakistan, Bangladesh, Indonesia, etc. In fall, the jamun trees grow up to 100 feet tall and produce clusters of fruits. Each cluster could contain fruits that have ripened, ranging from a handful to a dozen up to about forty fruits in each cluster. Quercetin, kaemferol, isoquercetin, ellagic aid, and anthocyanins are contained in Jambolan. *Syzygium cumini*, commonly called the Jamun or Java plum, is a tropical tree with great therapeutic uses. The seeds of this plant have conventionally been used in several medical systems like Ayurveda and Unani for varied ranges of treatments, from infections to gastrointestinal disorders to diabetes. Despite their long use traditionally, *Syzygium cumini* seeds have received scant attention in scientific literature until the recent past regarding pharmacological activities (Tambe et al., 2021).

Various studies on antibacterial activities revealed the seeds of *Syzygium cumini* to possess potent activities. Many ailments have traditionally used the antimicrobial activities of *Syzygium cumini* seeds as a herbal remedy. The seeds of *Syzygium cumini* owing to the high concentration of various phytochemicals, viz., phenolic compounds, saponins, tannins, and flavonoids, possess medicinal properties. In seeds, these bioactive phytoconstituents enhance the antimicrobial properties. *Syzygium cumini* seeds have enormous medicinal applications because of the synergistic action of phytochemicals present in them. Long since the practitioners of traditional medicine testified to the efficacy of *Syzygium cumini* seeds. What sets seeds apart is their antimicrobial properties (Nicolas et al., 2021). Further studies and clinical trials are essential to develop standardized extracts or formulations for therapeutic applications and also to understand the processes involved in these therapeutic benefits. This work aimed to contribute to the literature and provide more data supporting the therapeutic uses of *Syzygium cumini* seeds. There are some varieties of *Carica papaya* plants found in Indonesia. Almost all parts of this plant serve a culinary or therapeutic purpose for humans. Everyone may enjoy eating its leaves. The seeds have anthelmintic action, and the roots may be used as a medication for kidney and bladder problems. One form of enzyme that is used to tenderise meat is papain, and *Carica papaya* is the leaves that produce this enzyme. Protocatechuic acid, p-coumaric acid, 5,7-dimethoxycoumarin, caffeic acid, kaempferol, quercetin, and chlorogenic acid are some of the phenolic components found in *Carica papaya* leaf extracts. Research has shown that these chemicals may limit the development of Rhizopus stolonifer, in addition to having antibacterial action (Dadoosh, 2021).

Traditional healers would use a poultice made of the leaves to sore spots on the nerve system or elephantoid tumours. Smoking the leaves helped alleviate asthma in certain faraway places. The Javanese have a belief that eating *Carica papaya* will alleviate rheumatism. Humans may decrease their urine acidity by consuming *Carica papaya*, and the leaves have a history of usage in treating jaundice. Carpain, an active bitter alkaloid with a depressant effect on the heart, is present in the young leaves and, to a lesser extent, other sections. There is a potent amoebicide in the plant. The amount of each ingredient in the formulation determines how effective the therapy with *Carica papaya* will be. In Indonesia, animals are given a diet of cooked *Carica papaya* leaves every two days for a week after childbirth (Polido et al., 2021). No research on the use of *Carica papaya* leaf extracts as a profilaxis against malaria could be discovered in the literature, but it has been described.

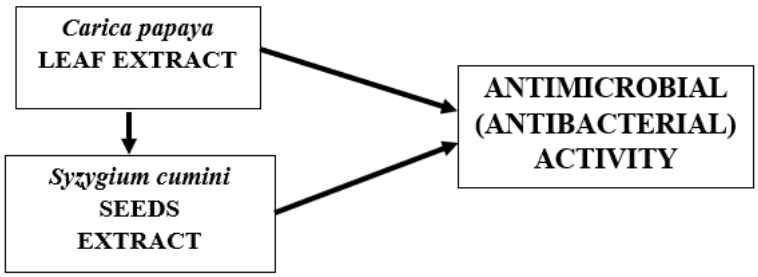
Uterine tumours and disorders of the smooth upper respiratory tract are among its Nigerian applications. The people of Ivory Coast use it to cure insanity. Its Trinidadian uses include the relief of hypertension and scorpion stings. Toothaches in cote d'Ivoire and Sama, as well as TB in Mexico, are treated with it. Used as a laxative, to ease constipation, and to treat liver problems in Honduras and Turkey. Arthritis and rheumatism are treated with it in the Philippines, India, Madagascar, and Malaya. Several countries utilise it as an abortion pill, including Turkey, Sri Lanka, Panama, and Java. It treats dysentery and diarrhoea in Honduras, Japan, Panama, and West Africa (Suriyaprom et al., 2022).

RESEARCH QUESTIONS:

- Which of the following extracts i.e., *Syzygium cumini* seeds extract and *Carica papaya* leaf extract have better antibacterial activities?

RESEARCH METHODOLOGY:

Conceptual Framework:



RESEARCH DESIGN:

Plant Materials Collection and Processing:

- ***Syzygium cumini* Seeds:**

Fresh *Syzygium cumini* seeds were obtained separately from a nearby farm. The University Department of Pharmacognosy and Natural Medicine was tasked with identifying and authenticating the species. The study involved the utilization of laboratory- *Syzygium cumini seeds* extract as the substances. Various reagents and other substances of laboratory quality were employed in the experiment.

- ***Carica papaya* Leaves:**

Fresh *Carica papaya* leaves were obtained separately from a nearby farm. The University Department of Pharmacognosy and Natural Medicine was tasked with identifying and authenticating the plant species. To eliminate any dust or debris that might have accumulated on the plant leaves, they were vigorously rinsed with tap water. After the dust removal process, the leaves were allowed to dry in the shade for an entire day. The subsequent step involved using an electric blender to pulverize the dried leaves.

- **Methanolic Extract of *Syzygium cumini* Seeds:**

A cold percolation technique was used in phases to extract the crude fraction using 80% methanol. In conical flasks, the dried and powdered materials were weighed and then steeped in methanol for 72 hours at room temperature, stirring occasionally. After 72 hours, the filtrate was transferred to beakers and the solvent was re-filtered using Whatman filter paper 41.

- **Aqueous Extract of *Carica papaya* Leaves:**

Fifty grams of powdered plant material was placed in a 500 mL conical flask, and 250 mL of distilled water was added. The flask was covered with aluminium foil and shaken continuously at 150 rpm for 24 hours on a reciprocating shaker to ensure thorough mixing. Subsequently, the extract was filtered using muslin cloth and Whatman no. 1 filter paper. The resulting solution was utilized for nanoparticle synthesis.

RESULTS:

Phytoconstituents of *Syzygium cumini* Seeds:

Following established protocols, the phytoconstituents of *Syzygium cumini* were determined in the seed extracts by analysing them for alkaloids, tannins, saponins, flavonoids, phenols, terpenoids, steroids, amino acids, and anthraquinone glycosides.

Phytoconstituents of *Carica papaya* Leaves:

The *Carica papaya* leaf aqueous extract includes flavonoids, saponins, and tannins, according to the results of the phytochemical screening.

Table 1: Phytochemical Screening Test of *Syzygium cumini Seed Extracts and Carica papaya* Leaves Extracts

Phytoconstituents	Solvents	
	Methanolic Extract of *Syzygium cumini* seeds	Aqueous Extract of *Carica papaya* leaves
Alkaloids	+	+
Tannins	+	+
Saponins	+	+
Flavonoids	+	+
Phenols	+	+
Terpenoids	+	+
Steroids	+	+
Amino acids	+	+
Anthra- quinone Glycosides	-	-

(+) = Presence of Phytoconstituents (-) = Absence of Phytoconstituents

Antibacterial Activity of *Syzygium cumini* Seeds:

Staphylococcus aureus, Bacillus subtilis, Salmonella typhi, and Escherichia coli, as illustrated in Table 2. Inhibitory zones were generated against all test species using methanol extracts. Inhibition zones had diameters between 6 and 22 millimetres. At a concentration of 100 µl, the methanol extract exhibited the greatest zone of inhibition (22 mm) against a few chosen typhoid-causing microorganisms, including Salmonella typhi. Several bacterial infections may be effectively treated using antibiotics derived from plant extracts. The medicinal potential of plants containing antimicrobial chemicals is immense since, unlike manufactured antimicrobial agents, they do not cause negative effects.

Antibacterial Activity of *Carica papaya* Leaves:

Table 2 shows the results of testing bacterial strains in lysed, non-infected human whole blood for the antibacterial activity of an aqueous *Carica papaya* leaf extract. The bacterial population was shown to be lower in the group treated with aqueous leaf extract at higher dosages compared to the control group. There was evidence of antibacterial action in the extract throughout this research.

Table 2: Antibacterial Activity of *Syzygium cumini* Seed Extracts *Carica papaya* Leaves Extracts

Test Organism	Zone of Inhibition (in mm)	
	Methanolic extract of *Syzygium cumini* Seeds	Aqueous Extract of *Carica papaya* Leaves
Bacillus subtilis	21.6	22.1
Staphylococcus aureus	22.9	25.2
Escherichia coli	23.6	24.8
Salmonella typhi	17.2	18.4

Antimicrobial Activity of *Syzygium cumini* Seeds:

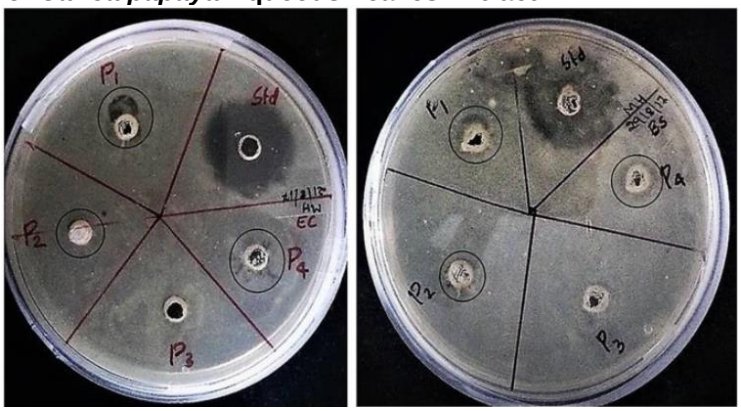
To determine whether Muller Hilton Agar plates have antibacterial properties, the Agar Well Diffusion Method was used. To prepare the Muller Hilton Agar plates, heat 6.46 grammes of MHA over 100 millilitres of distilled water in a conical flask that is placed on top of a hot plate until the mixture completely dissolves. After cotton-plugging the conical flask and covering it in aluminium foil, immediately put it through an autoclave at 121 degrees Celsius for fifteen minutes. After the medium was cooled to between 30 and 40 degrees Celsius at room temperature, it was transferred to autoclaved Petri dishes in a volume of 20 millilitres each plate. After an incubation period of twenty-four hours, the Petri plates were allowed to remain at room temperature.

Following the incubation process, any plates that were found to be contaminated were discarded, while the remaining plates were placed in the refrigerator until they were required once again.
By heating on a hot plate, 1.12 g of Nutrient Broth was dissolved in 40 mL of distilled water in a conical flask. Autoclaving the 5 mL tubes for testing for 15 minutes above 121 °C was the next step after transferring the solution. We sterilised and refrigerated the nutrient broth before continuing our investigation.
Moving the bacteria (the bacterium *Staphylococcus aureus, Bacillus subtilis, Salmonella typhi,* and *Escherichia coli*) from the main culture plate to a test tube with 5 mL of nutritional broth solution was done aseptically after examination and handling with an inoculating loop. The next step was to incubate the inoculums at 37 °C for one day. Zones for Inhibition (ZOI) using petri dishes were used to evaluate the antibacterial activity of plant extracts. A scale was used to quantify the inhibitory zone's diameter. Scientists specialising in pharmacognosy, and alternative medicine performed the microbiological tests at the institution.

Antimicrobial Activity of *Syzygium cumini* Methanolic Seed Extract

Antimicrobial Activity of *Carica papaya* Leaves:
Merck and Brataco supplied the chemicals utilised in this study (tween-80). In this study, papaya leaves ranging in length from 20 to 25 cm were used. After washing and drying the papaya leaves in the oven, they were ground into a powder. The leaf powder was macerated for 24 hours in a shaker incubator with three distinct solvents: Aqueous at 37 oC at 250 rpm. In order to get three distinct extracts, the mixture was filtered and then dried using a rotary evaporator. The agar diffusion technique was used to evaluate the antibacterial activity of all the extracts. To assess the antibacterial activity of those extracts, four types of bacteria were used: *Staphylococcus aureus, Bacillus subtilis, Salmonella typhi,* and *Escherichia coli*. Extracts from *Carica papaya* leaves exhibit antibacterial action, according to a small number of investigations.

Antimicrobial Activity of *Carica papaya* Aqueous Leaves Extract



DISCUSSION:
Antimicrobial activities of *Syzygium cumini* seeds extract have been compared with *Carica papaya* leaf extract, which provides valuable information on the potential of both as natural antibacterial agents. Though their therapeutic history spans centuries, the research described here points to the potent antibacterial potential of both plant extracts for the very first time against a range of noxious bacteria. The antibacterial activity of jamun or *Syzygium cumini* is because of the bioactive phytoconstituents such as tannins and flavonoids. Gram-positive bacteria, because of their thicker peptidoglycan layer, usually show more sensitivity to plant extracts; however, the finding results show the antibacterial potentiality of its seeds. It could be inferred that bioactive phytoconstituents present in *Syzygium cumini* seeds may interfere with bacterial growth either by interfering with its cell wall or interfering with its metabolic processes.

On the contrary, the versatile *Carica papaya* demonstrated an antimicrobial activity against a wide array of bacteria types. Papain and related enzymes and a variety of phytochemicals, for example, alkaloids and phenolic compounds have antibacterial attributes. From the findings, it can be noted that the leaf extract from *Carica papaya* has antibacterial activity and may possibly be a novel therapeutic agent for infections.
The present comparative study accordingly recommends that such extracts be clinically studied, since they are of natural origin and could well serve as a substitute for synthetic antibiotics. This is mainly needed since antibiotic resistance is also growing. One more hope could be entertained-trying to learn their mechanism of action against bacteria-leading to a new generation of antimicrobials. The present study adds to the known and speculates on integrity regarding an in-depth investigation into how these natural extracts may be employed in healthcare, particularly where traditional medicine is held in great regard.

CONCLUSION:

The results finally confirm that the natural extracts of *Syzygium cumini* seeds and *Carica papaya* leaves are truly deserving of becoming strong antimicrobial agents. In the antibacterial study of *Syzygium cumini* seeds, higher efficacy was observed toward Gram-positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*), while the extract from *Carica papaya* leaves affected a wider range of microorganisms, including Gram-negative (*Escherichia coli* and *Salmonella typhi*) ones. These findings have meanwhile put into relief the different phytochemical profiles of the two plants, which can serve as a backdrop to resistive variants in the development of new alternative antibiotics. Further studies to establish the mode of action for the identified activities of these extracts and their possible therapeutic applications are encouraged by the present results. This study contributes to the understanding of plant-based medicines' roles in modern medicine because it has established their application in combating bacterial diseases.

1. REFERENCES

2. Adelakun, A. O., Awosika, A., Adabanya, U., Omole, A. E., Olopoda, A. I., & Bello, E. T. (2024). Antimicrobial and synergistic effects of Syzygium cumini, Moringa oleifera, and Tinospora cordifolia against different Candida infections. Cureus, 16(1), e52857. https://doi.org/10.7759/cureus.52857
3. Ajiboye, A. E., & Olawoyin, R. A. (2020). Antibacterial activities and phytochemical screening of crude extract of Carica papaya leaf against selected pathogens. Global Journal of Pure and Applied Sciences, 26, 165-170.
4. Banthia, K., Baxi, M., Bhagat, D., et al. (2024). Comparative evaluation of effect of Syzygium cumini seed extracts and Psidium guajava leaf powder against periodontal pathogens: An in vitro study. World Journal of Dentistry, 15(6), 477-482.
5. Bukhari, A., Ijaz, I., Gilani, E., Nazir, A., Zain, H., Saeed, R., ... & Naseer, Y. (2021). Green synthesis of metal and metal oxide nanoparticles using different plants' parts for antimicrobial activity and anticancer activity: a review article. *Coatings*, *11*(11), 1374.
6. Dadoosh, R. M. (2021). Evaluation of phytochemical, total phenolic and antioxidant activity of carica papaya seed for its use in biosynthesis of gold nanoparticles. *Egyptian Journal of Chemistry*, *64*(8), 4301-4310.
7. Dagne, E., Dobo, B., & Bedewi, Z. (2021). Antibacterial activity of papaya (Carica papaya) leaf and seed extracts against some selected Gram-positive and Gram-negative bacteria. Pharmacognosy Journal, 13(6) Suppl, 1727-1733.
8. Ertas Onmaz, N., Demirezen Yilmaz, D., Imre, K., Morar, A., Gungor, C., Yilmaz, S., ... & Gungor, G. (2022). Green synthesis of gold nanoflowers using Rosmarinus officinalis and Helichrysum italicum extracts: Comparative studies of their antimicrobial and antibiofilm activities. *Antibiotics*, *11*(11), 1466.
9. Kaur, D., Yousuf, B., & Qadri, O. S. (2024). Syzygium cumini anthocyanins: Recent advances in biological activities, extraction, stability, characterisation and utilisation in food systems. Food Production, Processing and Nutrition, 6(1), 34.
10. Mahmoud, N. N., Sharaf, M., Shehata, A. M., Abd-Elhamed, W., Nada, R. S., Shawky, T. A., & Mekky, A. E. (2023). Bio-fabrication of silver nanoparticles using antioxidants-rich Syzygium cumini L. leaves extract with evaluation of its antibacterial, and anti-inflammatory activity. Al-Azhar Journal of Agricultural Research, 48(3), 460-474.
11. Nicolas, M. A., Alvine, N. M., Gaëtan, B. B. N., Kevin, M. D. Y., Darline, D., Alida, T. E. M., ... & Emmanuel, P. D. (2021). Bioguided isolation, structure elucidation and evaluation of new antimicrobial flavonoid from Carica papaya leaves. *Journal of Pharmacognosy and Phytochemistry*, *10*(1), 32-39.
12. Polido, A. C. B., Pizato, S., & Silva, K. D. S. (2021). Edible Coating with Jambolan (Syzigium cumini L.) Peel and Leaf Extracts to Reduce Color Changes, Mass Loss and to Increase β-Carotene Retention of Minimally Processed Papaya. *Anais da Academia Brasileira de Ciências*, *93*(4), e20200721.

13. Roshan, M., Singh, I., Vats, A., Behera, M., Singh, D. P., Gautam, D., ... & De, S. (2024). Antimicrobial and antibiofilm effect of cannabinoids from Cannabis sativa against methicillin-resistant Staphylococcus aureus (MRSA) causing bovine mastitis. *International Microbiology*, 1-14.
14. Shidiki, A., & Vyas, A. (2022). Evaluation of antibacterial potential of Syzygium cumini against methicillin-resistant Staphylococcus aureus and macrolide-lincosamide-streptogramin B strains of Staphylococcus aureus and its liquid chromatography mass spectroscopy analysis. Biomedical and Biotechnology Research Journal, 6(1), 66-72. https://doi.org/10.4103/bbrj.bbrj_139_21
15. Suriyaprom, S., Mosoni, P., Leroy, S., Kaewkod, T., Desvaux, M., & Tragoolpua, Y. (2022). Antioxidants of fruit extracts as antimicrobial agents against pathogenic bacteria. *Antioxidants*, *11*(3), 602.
16. Tambe, B. D., Pedhekar, P., & Harshali, P. (2021). Phytochemical screening and antibacterial activity of Syzygium cumini (L.) (Myrtaceae) leaves extracts. Asian Journal of Pharmaceutical Research and Development, 9(5), 50-54.
17. Vanlalveni, C., Lallianrawna, S., Biswas, A., Selvaraj, M., Changmai, B., & Rokhum, S. L. (2021). Green synthesis of silver nanoparticles using plant extracts and their antimicrobial activities: A review of recent literature. *RSC advances*, *11*(5), 2804-2837.