

Comparative Phytochemical, Antimicrobial Analysis of *Syzygium Cumini* (Seed) and *Allium Cepa* (Pulp) for Biomedical Applications

Shweta Chandel¹, Chetan Sharma², Indu Sharma³

^{1,2}Department of Zoology, NIMS Institute of Allied Medical Sciences and Technology, NIMS University, Rajasthan, Jaipur- 303121.

³Department of Biotechnology, NIMS Institute of Allied Medical Sciences and Technology, NIMS University, Rajasthan, Jaipur- 303121.

*Corresponding author: indu.sharma@nimsuniversity.org

ABSTRACT:

Phytochemical analysis of extracts from *Syzygium cumini* seeds and *Allium cepa* pulp, both acknowledged for their abundance of bioactive compounds, explained their chemical properties. Both extracts showed light absorption in the visible spectrum, with maximum absorbance at 400 nm for *S. cumini* and 420 nm for *A. cepa*, indicating the presence of conjugated bonds and chromophores. FTIR analysis identified peaks at 3288, 3257, and 3339 cm^{-1} , corresponding to O–H stretching vibrations, signifying hydrogen-bonded hydroxyl groups typical of alcohols and phenolics. The agar well diffusion method assessed antimicrobial activity against *Escherichia coli*, *Candida albicans*, and *Staphylococcus aureus*. *S. cumini* demonstrated a larger inhibition zone, especially against *C. albicans* (15.0 ± 0.0 mm) and *S. aureus* (14.0 ± 0.0 mm), while *A. cepa* was more effective against *E. coli* (15.0 ± 0.0 mm). One-way ANOVA showed significant differences for *E. coli* ($p = 0.0270$) and *C. albicans* ($p = 0.0168$), but not *S. aureus* ($p = 0.3040$). These results indicate that phenolic-rich ethanolic extracts of both plants have complementary antimicrobial activity, supporting their potential in polyherbal formulations for various biomedical conditions, including infectious, metabolic, diabetic, and neurodegenerative disorders.

Keywords: Phytochemical screening, UV-Vis spectroscopy, FTIR analysis, Seed extract, Pulp extract, Antimicrobial, Antioxidant therapy, Herbal therapy.

INTRODUCTION:

Across both developed and developing nations, there is a growing dependence on traditional medicine, with many individuals using plant-derived compounds to treat a wide range of health problem. Diabetes mellitus is a persistent metabolic condition marked by high blood sugar levels due to inadequate insulin production, insulin resistance, or metabolic issues. As of 2021, around 537 million people worldwide are living with diabetes, with estimates suggesting this number will rise to 643 million by 2030 and 783 million by 2045 (Singh et al., 2024). Besides its metabolic effects, diabetes can harm the kidneys, nerves, and cardiovascular system (Tella et al., 2024). Increasing research links type 2 diabetes mellitus (T2DM) to cognitive impairment (CI), including a higher risk of Alzheimer's disease. Although the exact mechanisms are not fully understood, factors like high blood sugar, oxidative stress, and disrupted insulin signalling are thought to play a role (Ling et al., 2018). Insulin resistance in T2DM is associated with neurodegeneration and altered glucose metabolism in the brain, similar to what is seen in Alzheimer's disease (Amir Rawa et al., 2022). In developing nations, about 80% of people use medicinal plants to manage diabetes (Arif et al., 2023). Herbal treatments are preferred over conventional drugs due to their lower cost, fewer side effects, and greater accessibility. Traditional therapies focus on lowering glucose levels, boosting insulin secretion, and enhancing insulin sensitivity. However, pharmacological treatments may have limited effectiveness and can cause side effects. Phytochemicals in medicinal plants, such as flavonoids, phenolics, alkaloids, and heterocyclic compounds, show antidiabetic, anti-inflammatory, and antioxidant properties. Compounds like ferulic acid, kaempferol, and ellagic acid are noted for their health benefits (Rashid et al., 2022). *Syzygium cumini* (Java plum) is a commonly used tropical plant in traditional Indian medicine for diabetes management. Its seeds contain flavonoids and alkaloids like jamboline and glycosides such as jambolin, which prevent the conversion of starch to sugar. Ellagic acid in the seeds has been shown to lower blood pressure by 34.6% and increase antioxidant activity (Franco et al., 2020; Hasan et al., 2023). *Allium cepa* (Onion) is also recognized for its medicinal properties. Rich in sulfur compounds like allyl propyl disulfide and flavonoids like quercetin, onions have antidiabetic, antibacterial, and cholesterol-lowering effects (Zhao et al., 2021). The compound S-methyl cysteine

sulfoxide helps in insulin production, reduces glucose absorption, and improves insulin efficiency (Sivakumar et al., 2023). A comparative analysis of the phytochemical profiles of *Syzygium cumini* and *Allium cepa* reveals unique secondary metabolites that contribute to their antidiabetic effects. UV-FTIR and antimicrobial analyses of selected plants were conducted, yielding promising results that highlight their potential therapeutic applications. These bioactive compounds hold potential for new drug development and serve as valuable natural additives in food and cosmetics, providing functional benefits without synthetic ingredients.

2. MATERIALS AND METHODS:

2.1 Plant Material Collection:

Fresh seeds of *Syzygium cumini* were procured from Himachal Pradesh, while *Allium cepa* bulbs were sourced from a local farm in Achrol, Rajasthan. Both plant materials underwent authentication, and the environmental conditions during collection were meticulously documented.

2.2 Preparation of Plant Extracts:

The plant samples were washed with distilled water, shade-dried for 10 days, and ground into a fine powder. The powdered material was stored in amber colored containers to prevent degradation. The extraction process used maceration with two solvents: distilled water and 95% ethanol. For each extract, 2 g of the powdered plant material was immersed in 50 mL of solvent for 72 hours at room temperature, with occasional stirring. Filtrates were collected using Whatman No.1 filter paper and concentrated using a rotary evaporator at a temperature of 40–45°C. The extracts were stored at 4°C until further use (Kadri & Minocheherhomji, 2020; Prasad et al., 2025).



Figure 1: Sample preparation for extraction was carried out using *Syzygium cumini* seeds, *Allium cepa* bulb in chopped pulp and powdered forms.

2.3 Qualitative and UV-Visible Spectroscopy, FTIR Analysis: Preliminary phytochemical screening was performed to detect the presence of alkaloids, flavonoids, tannins, phenolics, and saponins. UV-Visible spectroscopy (200–800 nm) was employed to identify characteristic phytochemical peaks. FTIR analysis (4000–400 cm^{-1}) was conducted to determine functional groups such as -OH, -COOH, and -NH (Nugrahani et al., 2025).

2.4 Antimicrobial Assay:

The antimicrobial activities were tested against *Escherichia coli*, *Candida albicans*, and *Staphylococcus aureus*. Standard laboratory strains were used and maintained on nutrient agar (for bacteria) and Sabouraud dextrose agar (for yeast). The agar well diffusion method was employed. Inoculum was prepared to match a 0.5 McFarland standard. Mueller–Hinton agar (bacteria) or Sabouraud dextrose agar (fungus) plates were inoculated with test microorganisms. Wells (6 mm diameter) were punched and loaded with 100 μl of each plant extract. Plates were incubated at 37°C for 24 h (bacteria) and 28 °C for 48 h (fungus). The zone of inhibition was measured in millimeters using a Vernier caliper (Aziz and Banerjee, 2018; Oyawoye et al., 2022).

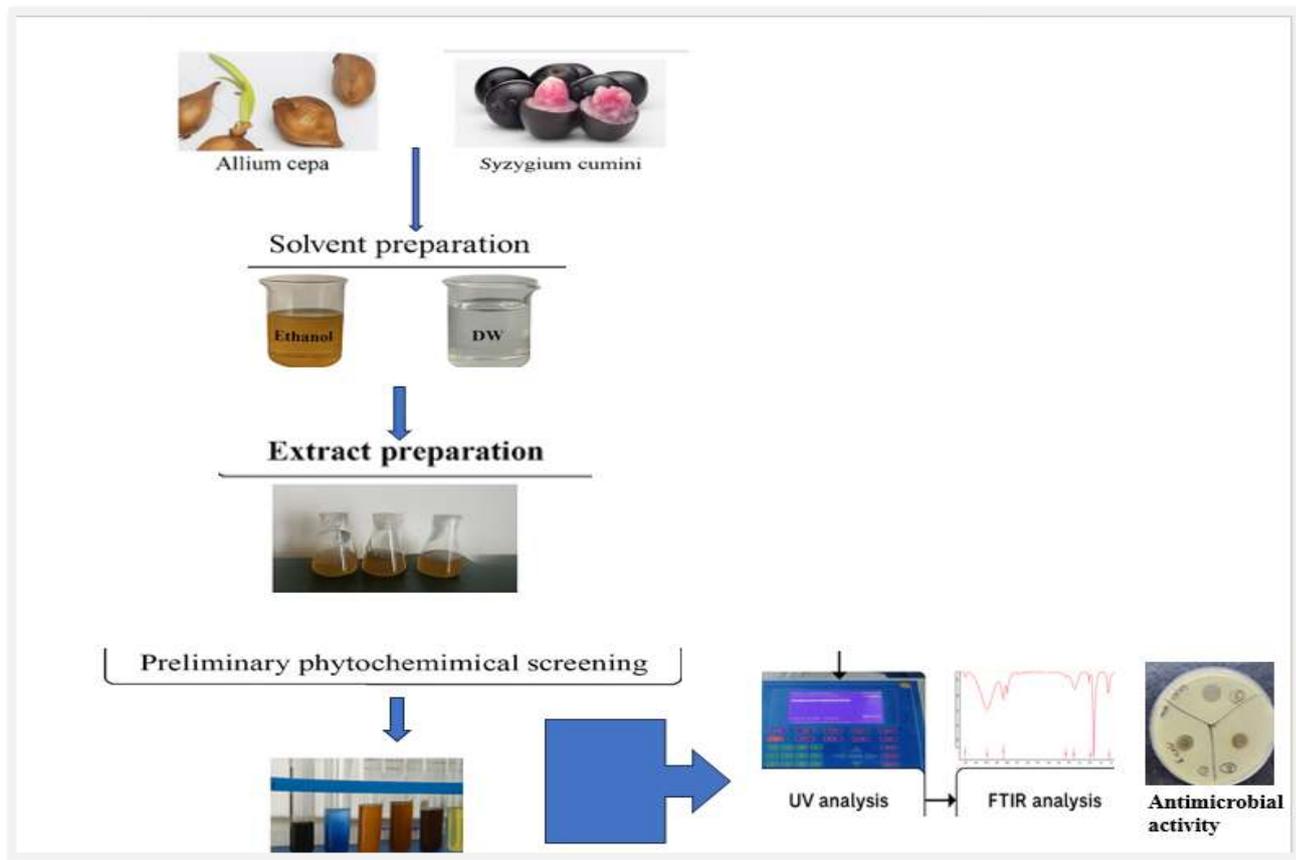


Figure 2: The figure depicts the systematic procedure commencing with the selection of *Syzygium cumini* (Black plum) and *Allium cepa* (Onion), followed by the preparation of extracts. These extracts subsequently underwent preliminary phytochemical screening through various qualitative tests, UV-visible spectrophotometry, FTIR analysis to identify functional groups and the presence of phytoconstituents, and antimicrobial assay.

3. RESULTS AND DISCUSSION

3.1 Phytochemical Screening of *Syzygium cumini* and *Allium cepa*

Phytochemical screening was carried out on methanolic and aqueous distilled water (DW) extracts of *Syzygium cumini* (Black Plum) seeds and *Allium cepa* (Onion) pulp to detect the presence of key bioactive constituents. The results are summarized below:

Table 1: Phytochemical Constituents Present in Ethanolic and Distilled water (DW) Plants Extracts (+ = Present, - = Absent)

Phytoconstituents	<i>S. cumini</i> (Ethanol)	<i>S. cumini</i> (DW)	<i>A. cepa</i> (Ethanol)	<i>A. cepa</i> (DW)
Alkaloids	+	+	+	+
Flavonoids	+	+	+	+
Phenols	+	+	-	+
Carbohydrates	-	+	+	-
Glycosides	+	-	-	-
Tannins	+	+	+	+
Proteins	+	+	+	-
Saponins	-	-	+	-

The phytochemical analysis revealed the presence of various bioactive compounds in both *Syzygium cumini* (Black Plum) and *Allium cepa* (Onion), using ethanol and distilled water as extraction solvents. The distribution and intensity of phytoconstituents varied depending on the plant species and the solvent used. When analyzing *Allium cepa* (Onion) pulp and *Syzygium cumini* (Black plum) seeds with ethanol and distilled water, distinct bioactive profiles emerged, contingent on the solvent. The extracts consistently showed the presence of alkaloids and flavonoids, indicating significant antioxidant and

antidiabetic properties. Carbohydrates were water-soluble in both species, while phenols were abundant in *S. cumini* but only extracted in *A. cepa*, appearing exclusively in its aqueous form. Notably, only the ethanolic extract of *S. cumini* contained glycosides, highlighting methanol's effectiveness in extracting compounds linked to hypoglycemic effects. Tannins were present in all plant samples, enhancing their astringent and antibacterial properties. Saponins appeared only in the ethanolic extract of *A. cepa*, indicating solvent-dependent selectivity, while proteins were generally present, except in the aqueous extract of *A. cepa* (Banerjee et al., 2011; Arora et al., 2017).

3.2 US-Vis Spectroscopy and FTIR Analysis

Spectral Characterization via UV-Vis and FTIR analysis by using ethanol and distilled water as solvents, the UV-visible spectroscopic analysis of extracts from *Syzygium cumini* and *Allium cepa* showed different absorption profiles, which indicate how well each solvent extracts phytochemical constituents.

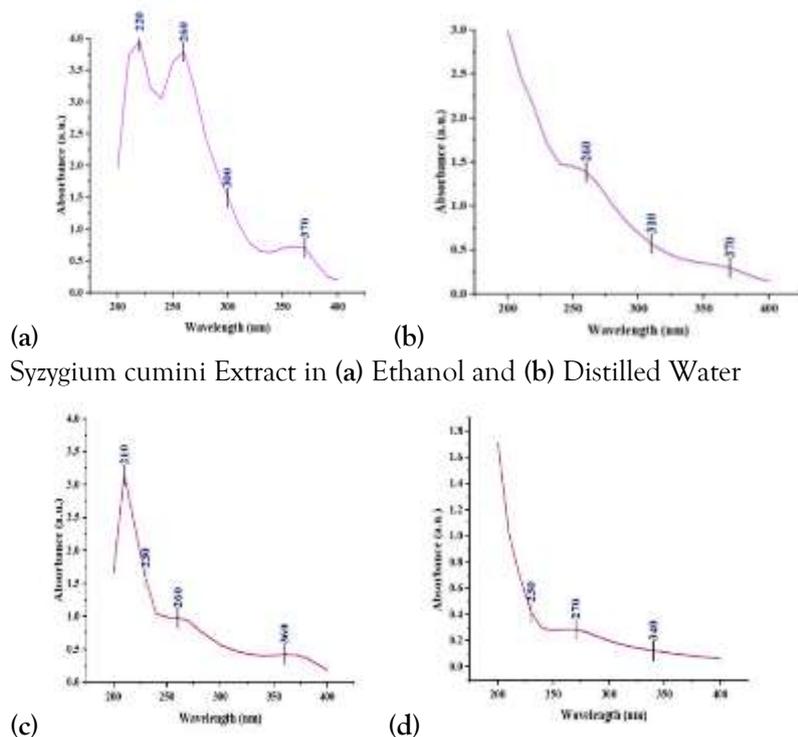
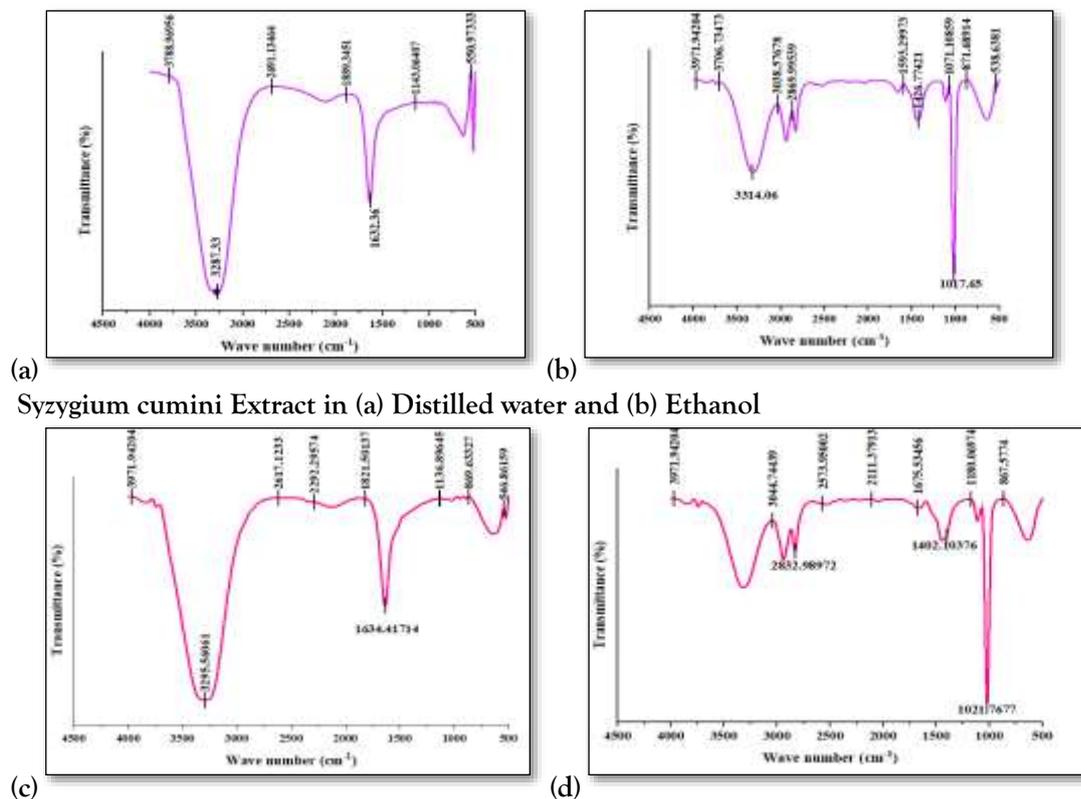


Figure 2: (a–d): UV-Visible absorption spectra of *Syzygium cumini* and *Allium cepa* extracts in ethanol and distilled water showing peaks between 210–370 nm; ethanol extracts (a, c) displayed multiple strong peaks indicating phenolic, flavonoid, and sulfur compounds, while distilled water extracts (b, d) showed fewer, lower-intensity peaks, suggesting limited extraction of polar phytochemicals.

With the highest absorbance at 250 nm (~3.3 a.u.), the ethanol extract of *Syzygium cumini* showed several prominent absorption peaks at 210 nm, 250 nm, 280 nm, 320 nm, and 370 nm (Kaur et al., 2024). This suggested a rich composition of bioactive compounds, including flavonoids, phenolic acids, and possibly anthocyanins. In contrast, its distilled water extract showed a lower absorbance (~2.0 a.u.) and fewer peaks at 260 nm, 310 nm, and 370 nm, indicating a limited extraction of primarily polar constituents. The ethanol extract of *Allium cepa* also demonstrated strong absorption at 210 nm, 250 nm, 280 nm, and 320 nm, with the highest absorbance at 210 nm (~3.7 a.u.).

These results suggested the presence of sulfur-containing compounds, flavonoids, and quercetin, which are typical of the onion family. The *Allium cepa* distilled water extract, on the other hand, showed only slight peaks at 250 and 270 nm with a comparatively low absorbance (~1.6 a.u.), underscoring the reduced effectiveness of water in extracting a wide variety of phytochemicals (Kim et al., 2010) (Figure 2). Ethanol worked better as a solvent for both plant samples, producing greater absorbance intensities and a wider variety of spectral peaks. Ethanol efficiently extracts both polar and somewhat nonpolar compounds, demonstrating that solvent polarity is an important factor in phytochemical extraction.



Syzygium cumini Extract in (a) Distilled water and (b) Ethanol

Allium cepa Extract in (a) Distilled water and (b) Ethanol

Figure 3(a-d): FTIR spectra of *Syzygium cumini* and *Allium cepa* ethanol and distilled water (DW) extracts showing characteristic peaks for functional groups such as O-H, C=O, C-O, N-H, and C-H; ethanol extracts (b, d) revealed stronger, broader peaks indicating diverse phytochemicals, while distilled water extracts (a, c) showed comparatively weaker bands, reflecting limited polar compound extraction.

The FTIR spectrum of the aqueous extract of *Allium cepa* reveals a complex phytochemical composition (Figure 3a). A broad absorption band at 3295.56 cm^{-1} indicates the presence of hydroxyl-containing compounds, such as phenolics, flavonoids, and glycosides. A higher frequency peak at 3971.94 cm^{-1} supports the presence of free hydroxyl groups or residual water molecules. The peak at 2617.12 cm^{-1} suggests the presence of organosulfur compounds, which are characteristic of *Allium cepa*. A weak absorption at 2292.26 cm^{-1} may be attributed to C≡C stretching or CO₂ overtones. A distinct band at 1821.50 cm^{-1} corresponds to C=O stretching vibrations, indicative of carbonyl groups in esters, lactones, or anhydride-like structures (Verma et al., 2018). A sharp peak at 1634.41 cm^{-1} is characteristic of C=C stretching in aromatic rings, commonly associated with flavonoids and polyphenols. The Fourier-transform infrared (FTIR) spectrum of the ethanolic extract of *Allium cepa* reveals the presence of several functional groups indicative of bioactive phytochemicals (Figure 3b). The spectrum shows O-H stretching vibrations of free hydroxyl groups, aromatic rings or unsaturated alkenes, C-H stretching of aldehydic groups, S-H stretching vibrations, C≡C or C≡N stretching, C=O stretching of conjugated carbonyl groups, aromatic skeletal vibrations, C-O-C or C-N stretching, prominent C-O stretching vibrations from polysaccharides, glycosidic linkages, or primary alcohols, and aromatic C-H bending, confirming the presence of aromatic phytoconstituents. These findings suggest that the ethanolic extract of *A. cepa* contains a complex mixture of flavonoids, phenolic compounds, sulfur-containing bioactives, and carbohydrates. The FTIR analysis of the aqueous extract of *Syzygium cumini* revealed distinct absorption bands corresponding to various bioactive functional groups, indicating the presence of phytochemicals with potential therapeutic properties (Figure 3c). The broad bands at 3287.33 cm^{-1} and 2691.13 cm^{-1} confirm the polyphenol-rich nature of the extract. The absorption bands at 1889.35 cm^{-1} and 1632.36 cm^{-1} correspond to O-H stretching vibrations, suggesting the presence of aldehydes, conjugated ketones, or oxidized polyphenols. The C-O-C stretching vibrations at 1143.06 cm^{-1} suggest the presence of glycosides, carbohydrates, or ether-linked flavonoids. The low-intensity band at 550.97 cm^{-1} may reflect metal oxygen interactions, sulfur-containing groups, or skeletal bending vibrations commonly associated with complex plant polyphenols. The FTIR spectrum of the ethanolic extract of *Syzygium cumini* revealed

several prominent absorption bands, indicating the presence of bioactive phytochemicals (Figure 3d). Broad peaks at 3971.94 cm^{-1} , 3706.73 cm^{-1} , and 3314.06 cm^{-1} correspond to O-H stretching vibrations of hydroxyl groups, indicating the abundance of polyphenols, flavonoids, tannins, and residual moisture. The absorption bands at 3083.57 cm^{-1} , 2869.99 cm^{-1} , 1593.30 cm^{-1} , 1426.77 cm^{-1} , 1071.11 cm^{-1} , 1017.65 cm^{-1} , 871.68 cm^{-1} , and 538.63 cm^{-1} suggest aromatic C-H out-of-plane bending and potential metal-oxygen or sulfur-containing skeletal vibrations (Banerjee et al., 2011). *Syzygium cumini* is rich in diverse functional groups, including hydroxyls, carbonyls, aromatics, ethers, and polysaccharides, supporting its traditional use and previously reported antioxidant, antimicrobial, and therapeutic properties. Utilizing UV-Vis and FTIR analyses, it was determined that ethanolic extracts of both *Syzygium cumini* and *Allium cepa* demonstrated superior phytochemical profiles. Consequently, ethanol was chosen as the extraction solvent for subsequent antimicrobial assays

3.3 Descriptive Statistics: mean \pm SD of inhibition zones (mm) are presented in Table 2. for *E. coli*, *S. cumini* showed a mean zone of 13.0 ± 0.0 mm, whereas *A. cepa* exhibited 15.0 ± 0.0 mm. Against *Candida albicans*, *S. cumini* recorded 15.0 ± 0.0 mm, while *A. cepa* showed 12.0 ± 0.0 mm. For *Staphylococcus aureus*, *S. cumini* achieved 14.0 ± 0.0 mm and *A. cepa* 13.0 ± 0.0 mm in ethanolic extract (Aziz, Banerjee, 2018; Oyawoye et al., 2022).

Table 2. Mean \pm SD of antimicrobial activity of the Ethanolic plant extract.

Microbes	Treatment	Mean \pm SD (mm)
<i>Escherichia coli</i>	<i>S. cumini</i>	13.0 ± 0.0
<i>Escherichia coli</i>	<i>A. cepa</i>	15.0 ± 0.0
<i>Candida albicans</i>	<i>S. cumini</i>	15.0 ± 0.0
<i>Candida albicans</i>	<i>A. cepa</i>	12.0 ± 0.0
<i>Staphylococcus aureus</i>	<i>S. cumini</i>	14.0 ± 0.0
<i>Staphylococcus aureus</i>	<i>A. cepa</i>	13.0 ± 0.0

Inferential Statistics One-way ANOVA revealed statistically significant differences between the two plant extracts for *E. coli* ($F = 7.000$, $p = 0.0270$) and *Candida albicans* ($F = 8.714$, $p = 0.0168$). No significant difference was found for *Staphylococcus aureus* ($F = 1.462$, $p = 0.3040$).

Table 3. One way ANOVA results for *Escherichia coli*, *Candida albicans*, and *Staphylococcus aureus*

Microbe	F-value	p-value	Result
<i>Escherichia coli</i>	7.000	0.0270	Significant
<i>Candida albicans</i>	8.714	0.0168	Significant
<i>Staphylococcus aureus</i>	1.462	0.3040	Not significant

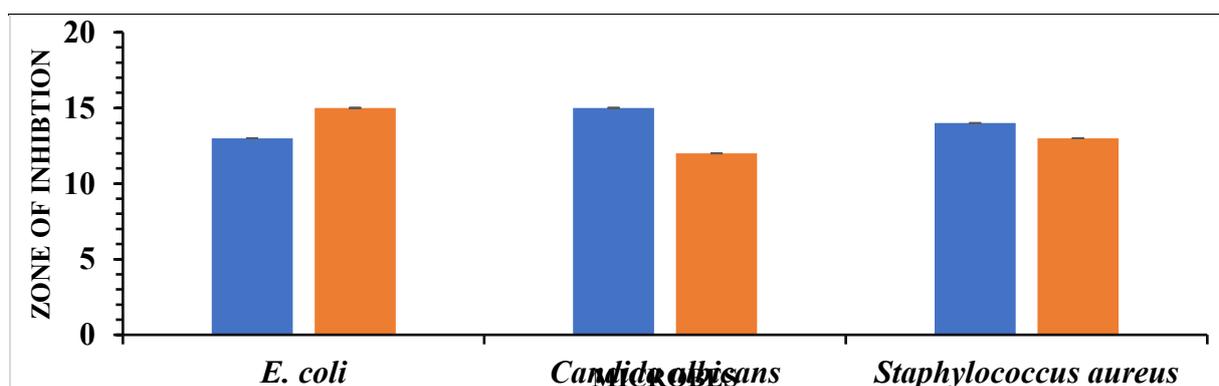


Figure 4: Present bar charts with error bars (\pm SD) and boxplots for each microbe. For *Escherichia coli* and *Candida albicans*, *S. cumini* (-) demonstrated superior inhibitory activity (zone of inhibition) compared to *A. cepa* (-), whereas differences for *Staphylococcus aureus* were minimal.

Comparative antimicrobial activity of *Syzygium cumini* and *Allium cepa* extracts against *E. coli*, *Candida albicans*, and *Staphylococcus aureus*. Bars represent the mean zone of inhibition (mm) \pm standard deviation (Figure 4). Significant differences ($p < 0.05$) are indicated above bars. The antimicrobial properties observed are consistent with the established phytochemical compositions of both plants in their ethanolic extracts. The greater inhibition of *E. coli* by *A. cepa* may be attributed to sulfur-containing compounds such as allicin, which are effective against Gram-negative bacteria. Conversely, the enhanced antifungal activity of *S. cumini* against *C. albicans* could be due to its tannins and ellagic acid derivatives, which interfere with fungal cell walls and inhibit enzymatic functions. The absence of a significant difference in activity against *S. aureus* suggests that both extracts may employ similar antibacterial mechanisms on Gram-positive bacteria. Overall, these results support the traditional use of *S. cumini* and *A. cepa* as natural antimicrobial agents and provide quantitative evidence for their potential in preventing or managing microbial infections.

3.4 Mechanistic Insights

Flavonoids and phenolic compounds present in both plants play a crucial role in modulating glucose metabolism, reducing oxidative stress, and preserving neuronal integrity. Their synergistic effects enhance therapeutic outcomes and offer potential for biomedical applications, including the development of neuroprotective agents, antidiabetic formulations, and antioxidant-based drug delivery systems. These bioactive compounds may further contribute to the design of functional foods and nutraceuticals to manage chronic metabolic and neurodegenerative disorders.

3.5. CONCLUSION:

The ethanolic extracts of *Syzygium cumini* and *Allium cepa* demonstrate a comprehensive phytochemical profile, as evidenced by FTIR and UV-Vis spectroscopic analyses, which reveal a high concentration of phenolic compounds and a variety of bioactive functional groups. These molecular characteristics are strongly correlated with their significant antimicrobial activities. *A. cepa* exhibits superior efficacy against *E. coli*, whereas *S. cumini* shows greater inhibition of *Candida albicans*, with both extracts displaying comparable effects on *Staphylococcus aureus*. Phytochemical screening further corroborates the presence of elevated levels of flavonoids and phenolics, underscoring their therapeutic potential. Notably, the synergistic combination of these plant extracts may present promising biomedical applications, particularly in the management of type 2 diabetes and its associated cognitive decline. Their antioxidant and neuroprotective properties suggest potential in the development of multifunctional therapeutics, including antidiabetic agents, neuroprotective supplements, and antimicrobial formulations. To translate these findings into clinical relevance, further investigation using *in vivo* models and rigorous clinical trials is imperative. Additionally, advanced analytical techniques such as HPLC and LC-MS are necessary to accurately identify and quantify the active constituents, thereby facilitating standardized, targeted drug development.

4. Future Perspectives

- In vivo studies to validate neuroprotective and antidiabetic effects.
- Develop standardized formulations combining these plant extracts.

5. Acknowledgments.

We would like to thank NIMS University, Rajasthan, Jaipur, for providing laboratory facilities and unwavering support throughout the course of this research. Their infrastructure, technical assistance, and academic environment played a pivotal role in enabling the successful execution of our experimental work. We are also grateful to the faculty and staff for their valuable guidance, encouragement, and timely inputs that enriched the quality of this study.

REFERENCES:

1. Singh, R., Shafikhani, SH., & Gholipourmalekabadi, M. Animal models for type 1 and type 2 diabetes: advantages and limitations. *Frontiers in Endocrinology*, 15.2024; <https://doi.org/10.3389/fendo.2024.1359685>.

2. Tella T, Pohl C, Igor KA review on diabetes mellitus: complications, synthetic anti-diabetic agents, and herbal treatments. F1000 Res; 2024. <https://doi.org/10.12688/f1000research.141015.1>
3. Ling HongYan LH, Zhu ZeMei ZZ, Yang JiHua YJ, He JianQin HJ, Yang SiSi YS, Wu Di WD, Feng ShuiDong FS, Liao DuanFang LD. Dihydropyridin improves type 2 diabetes-induced cognitive impairment by suppressing oxidative stress and enhancing brain-derived neurotrophic factor-mediated neuroprotection in mice. 2018; <https://doi.org/10.1093/abbs/gmy003>.
4. Amir Rawa MS, Mazlan MK, Ahmad R, Nogawa T, Wahab HA. Roles of *Syzygium* in anti-cholinesterase, anti-diabetic, anti-inflammatory, and antioxidant activities: from a perspective on Alzheimer's. *Plants*. 2022 May 31;11(11):1476. <https://doi.org/10.3390/plants11111476>.
5. Arif M, Parveen R, Tiwari SB, Singh SD. The potential antidiabetic activity of phytonutrients against type 2 diabetes mellitus: a review of in-vitro and in-vivo studies. *China Petroleum Processing and Petrochemical Technology*. 2023.
6. Singh K, Alam MI, Phalke E, Lakshman K. Traditional diabetes care with herbal medicine. *World J Pharm Pharm Sci*. 2023;11(11). doi:10.20959/wjpps202311-26054.
7. Rashid F, Javaid A, Ashfaq UA, Sufyan M, Alshammari A, Alharbi M, Nisar MA, Khurshid M. Integrating pharmacological and computational approaches for the phytochemical analysis of *Syzygium cumini* and its anti-diabetic potential. *Molecules*. 2022 Sep 5;27(17):5734. <https://doi.org/10.3390/molecules27175734>
8. Franco RR, Zabisky LF, de Lima Júnior JP, Alves VH, Justino AB, Saraiva AL, Goulart LR, Espindola FS. Antidiabetic effects of *Syzygium cumini* leaves: a non-hemolytic plant with potential against oxidation, glycation, inflammation, and digestive enzyme catalysis. *Journal of Ethnopharmacology*. 2020 Oct 28;261:113132. <https://doi.org/10.1016/j.jep.2020.113132>
9. Hasan SE, Jubayer A, Akter K, Akter A, Akter F, Al Shiam SA, Sunny AR. Effects of *Nigella sativa* and *Syzygium cumini* seed extracts on blood glucose levels in Swiss albino mice. *Journal of Knowledge, Learning, and Science Technology*. DPP-4 inhibition by linagliptin ameliorates age-related mild cognitive impairment by regulating microglia polarization in mice. <https://doi.org/10.60087/jklst.vol2.n3.p62.11>.
10. Zhao XX, Wang Y, Gan RY, Li H, Wu DT, Ma W, et al. Recent Advances in Bioactive Compounds, Health Functions, and Safety Concerns of Onion (*Allium cepa* L.). *Front Nutr*. 2021 July 22;8. <https://doi.org/10.3389/fnut.2021.669805>.
11. Sivakumar T, Deepa BA critical review on the antidiabetic potential of herbal plants and their bioactive components. *J Univer Shanghai Sci Tech*. 2023;25(01):303-14.
12. Prasad PK, Biswas SM, Chattopadhyay RR. A comparative evaluation of the antibacterial and antioxidant potential of phenolic-rich hydro-ethanol extracts of leaf, seed, and fruit pulp of *Syzygium cumini* (L.) Skeels alone and in combination. *Journal of Medicinal Plants Studies*. 2025;13(1a):1-9. doi:10.22271/plants.2025.v13.i1a.1786.
13. Kadri HS, Minocheherhomji FP. ADMET analysis of phyto-components of *Syzygium cumini* seeds and *Allium cepa* peels. *Future Journal of Pharmaceutical Sciences*. 2020;6(1):117. doi:10.1186/s43094-020-00136-9.
14. Nugrahani, NA., Widyastuti, NH., Anggraeni, CNY., & Kholifa, M. (2025). Analyzing aloe vera and avocado seed extracts for antioxidants, saponins, tannins, flavonoids, and alkaloids using the UV-VIS spectrophotometric method. *F1000Research*, 14, 36. <https://doi.org/10.12688/f1000research.157091.1>
15. Aziz A, Banerjee S. Phytochemical screening and antibacterial activity study of *Syzygium cumini* (Myrtaceae) seed extracts. *Pharmatutor*. 2018 Apr 1;6(4):70-3.
16. Oyawoye OM, Olotu TM, Nzekwe SC, Idowu JA, Abdullahi TA, Babatunde SO, Ridwan IA, Batiha GE, Idowu N, Alorabi M, Faidah H. Antioxidant potential and antibacterial activities of *Allium cepa* (onion) and *Allium sativum* (garlic) against the multidrug-resistant bacteria. *Bulletin of the National Research Centre*. 2022 Jul 18;46(1):214. <https://doi.org/10.1186/s42269-022-00908-8>.
17. Selvaganesh C, Sadhana B. High-performance liquid chromatographic analysis and antibacterial activity of methanolic seed extract of *Syzygium cumini* L. *Research & Reviews: Journal of Herbal Science*. 2022;11(2). <https://doi.org/10.37591/rrjohs.v11i2.3417>.
18. Arora E, Sharma V, Khurana A, Manchanda A, Sahani D, Abraham S, Kundu D, Gupta H, Chiru L. Phytochemical analysis and evaluation of antioxidant potential of ethanol extract of *Allium cepa* and ultra-high homeopathic dilutions available on the market: a comparative study. *Indian Journal of Research in Homeopathy*. 2017;11(2):88-96.
19. Kaur, D., Yousuf, B., & Qadri, OS *Syzygium cumini* anthocyanins: recent advances in biological activities, extraction, stability, characterization, and utilization in food systems. *Food Production, Processing, and Nutrition*, 2024; 6(1). <https://doi.org/10.1186/s43014-023-00177-6>
20. Kim MH, Kwon YI, Jo SH, Jang HD, Lee MS. Antioxidant activity and α -glucosidase inhibitory potential of onion (*Allium cepa* L.) extracts. *Food Science and Biotechnology*. 2010 Feb 1;19(1):159-164. <https://doi.org/10.1007/s10068-010-0022-1>.
21. Verma M, Singh SS, Rose NM. Phytochemical screening of onion skin (*Allium cepa*) dye extract. *Journal of Pharmacognosy and Phytochemistry*. 2018;7(6):1414-1417.

22. Banerjee J, Narendhirakannan RT. Biosynthesis of silver nanoparticles from *Syzygium cumini* (L.) seed extract and evaluation of their in vitro antioxidant activities. *Digest Journal of Nanomaterials and Biostructures*. 2011 Jul 1;6(3):961-968.