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Study on Morphology, Anatomy, Phytochemical and Antimicrobial Activity of *Terminalia catappa* L. Leaves

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A B S T R A C T

Natural products derived from microbes, plants, and animals offer a broad variety of molecules and chemical compounds. Natural products are not only one of the most important sources for innovative drug development for animal and human health, but they are also an inspiration for synthetic biology and chemistry scientists towards the discovery of new bioactive compounds and pharmaceuticals. This is particularly relevant in the current context, where antimicrobial resistance has risen as a global health problem. Phytochemical screening of *T catappa* L plant leaf was done in hot water, cold water, ethanol and methanol extract. Tannin, quinine, terpenoid, flavonoid, steroid, alkaloid, cardiac glycoside, glycoside, volatile oils, etc were the phytoconstituents found in plants. The existence of these secondary metabolites has been noted to contribute to the antimicrobial activity exhibited by plants. The phytoconstituents present in the plant extract showed an effect on bacterial and fungal culture. This study utilized two bacterial cultures, *Bacillus cereus* and *Escherichia coli*, to evaluate the extract's efficacy. *E. coli* displayed the greatest inhibition with methanol extract at 22 mm. *Bacillus cereus* exhibited the highest inhibition zone with methanol at 20.66 mm. The cultures of *Aspergillus terreus* exhibited the greatest zone of inhibition (21 mm) for the methanol extract, using the Agar well diffusion method while Disc Diffusion method shown highest zone of inhibition for ethanol 17 mm. *Aspergillus flavus* exhibited the greatest zone of inhibition at 15 mm for ethanol, using the agar well diffusion method. The Disc diffusion method displayed the greatest zone of inhibition with cold water at 11 mm. The findings from both the Disc and well diffusion methods indicate that the well diffusion method is superior for antifungal research. Hence these plants could be used to develop drugs and also may be effective against fungi and bacteria.

Introduction

Medicinal plants are crucial plant species that, based on traditional healing methods and contemporary scientific research, are beneficial for medical use in easing ailments and enhancing human health. These plants are regarded as abundant sources of compounds that can be utilized in drug synthesis and manufacturing (Oladeji *et al.,* 2019). Plants are made up of different types of chemical compounds referred to as phytoconstituents.

Natural products and their derivatives demonstrate fewer side effects and enhanced effectiveness compared to other synthetic alternatives. Plant-derived compounds such as flavonoids, quinine, terpenoids, and others perform specific biological roles that boost therapeutic effects including anti-carcinogenic, anti-mutagenic, anti-inflammatory, and antioxidant attributes (Batiha *et al.,* 2020). Traditional medicine has been utilized for centuries across various regions globally, particularly in India's rural areas, owing to its accessibility and affordability. For thousands of years, nature has offered medicinal compounds, and a significant number of contemporary pharmaceuticals have been extracted from these natural sources, often inspired by their application in traditional healing practices (Chanda *et al.,* 2011).

Since ancient times, plants have been utilized for medicinal purposes. The application of phytochemicals in medicine represented a significant advancement in health science by potentially reducing the reliance on antibiotics (Gangadher *et al.,* 2023). Plants contain a diverse range of secondary metabolites, including tannins, alkaloids, phenolic compounds, quinones, and flavonoids, which have demonstrated antimicrobial properties in vitro. Several phytotherapy guides have listed different medicinal herbs for addressing infectious diseases such as urinary tract infections, gastrointestinal disorders, respiratory illnesses, and skin infections. For millennia, nature has served as a source of medicinal compounds, and a significant number of contemporary pharmaceuticals have been extracted from natural origins, often inspired by their applications in traditional healing practices. Consequently, discovering new antimicrobial agents is extremely crucial. (Lalam, 2019). The occurrence of multiple resistances in human pathogenic microbial strains has been rising, primarily because of the unrestricted use of synthetic antimicrobial medications that are frequently utilized in treating infectious diseases. The emergence of bacterial resistance to current antibiotics has prompted the exploration of new antibacterial agents. To address this issue, research has been undertaken with different medicinal plants, assessing antimicrobial activity and identifying new antimicrobial compounds and antioxidant activity (Praveena, 2014).

Terminalia catappa L. is a member of the Combretaceae family. *T. catappa* L. serves mainly as an ornamental, shade, and salt-resistant street tree, yet its leaves feed the tasar silkworm, and its seeds are edible, resembling almonds in oil content. Every part of this plant is primarily utilized for conventional healing. For instance, leaves are utilized in ointments for scurvy, leprosy, and various skin ailments; fruit helps in addressing bronchitis, colon issues, and diabetes; root bark is applied for dysentery, diarrhea, and acts as an antimicrobial. The seeds serve as a source of nutrition, energy, and vegetable oil and can be transformed into different types of food products. The fruit has ascorbic acid; it has a bitter and astringent flavor. The bark has tannins, whereas the seeds hold oil. The leaves of the Terminalia catappa L. plant have been widely researched, particularly for their antibacterial and antifungal properties. The leaves of Terminalia catappa L. in aquaculture have been known for their antibacterial and antifungal properties for a long time; this practice continues to be utilized. (Yastanto and Indrati, 2024). In India, a poultice made from T. catappa L. leaves is applied to treat scabies, leprosy sores, and various skin conditions. Its conventional application involves addressing diarrhea and fever, particularly in India, the Philippines, and Malaysia. (Terças *et al.,* 2017)

The anatomical characteristics of leaves are dorsiventral, featuring an anomocytic stoma on the underside. Stomata are not present on the upper surface, and the epidermal cells have a wavy appearance. The palisade mesophyll cell consists of a single layer, cylindrical, stretched, and closely packed. The mesophyll cells are mostly irregularly shaped, parenchymatous cells containing intercellular spaces. The midrib has a gentle convex shape and is covered with a smooth cuticle. The cells of the upper epidermis have a barrel shape. The vascular bundle in the petiole is crescent-shaped and collateral. A basic unicellular trichome is found (Zan, 2019).

Terminalia catappa L. contains various phytochemical components like alkaloids, amino acids, flavonoids, glycosides, phenolic substances, saponins, steroids, sugars, and tannins that enhance its biological functions. The leaves of this plant are said to possess antimalarial properties due to their alkaloid content. Additionally, the flavonoids present in the leaves of this tree are viewed as key contributors to their antimicrobial properties against various bacteria. The concentration required to attain all functionalities differs, and safety issues emerge for consumers regarding the applications of the extract's concentration (Madhavan *et al.,* 2023).

The primary goals of this paper are to investigate the morphological features of the vegetative and reproductive components of Terminalia catappa L., to

understand the anatomical characteristics of its leaves, to identify the preliminary phytochemical constituents and antimicrobial properties derived from the leaves, and to examine the medicinal significance and applications of *Terminalia catappa* L.

Materials and Methods

Collection and Morphological Identification of *Terminalia catappa*

The samples of *Terminalia catappa L.* were collected from the grounds of Indira Priyadarshini College, Chhindwara, Madhya Pradesh between March and April in 2024. Fresh samples of vegetative and reproductive components were utilized to examine its morphology (Zan, 2019).

Preparation for Anatomical Studies

For the anatomical investigations, epidermal peels from both the upper and lower surfaces of the lamina were utilized and examined through staining. The transverse section of the midrib and petiole of fresh leaves was cut into thin slices using a razor blade for freehand sectioning. The sliced samples were made clear by using water as a clearing agent. The specimens were dyed with safranin, mounted using glycerine, and a cover slip was applied. The prepared slides were subsequently analyzed using light microscopes and documented with photographs (Punwong *et al.,* 2017).

Processing of plant materials

The freshly gathered leaves of *Terminalia catappa L.* were washed with tap water to remove dust and dirt, then air-dried in the shade at room temperature for 2 weeks. The dried leaves are ground to a powder using an electric grinder (Segaran *et al.,* 2019).

Extract Preparation

10 grams of leaf powder was mixed with 100 ml of various solvents including ethanol, cold water, hot water, and methanol, then left in the shaker overnight. The mixture was subsequently filtered with Whatman filter paper No. 1 to obtain a solid-free solution, and after labelling, the extract was stored in the refrigerator for additional studies (Segaran *et al.,* 2019).

Screening for Phytochemicals

Four distinct extracts were examined to assess the presence of alkaloids, amino acids, carbohydrates, fixed oils and fats, glycosides, phytosterols, proteins, saponins, gum and mucilage, steroids, terpenoids, tannins, flavonoids, and anthraquinones.

The techniques outlined by Marathe *et al.,* 2022, with minor adjustments, were employed to assess the existence of the active compounds in the leaf extracts.

Test for Alkaloids

A. Mayer's test: In 1 ml of plant extract, two drops of Mayer's reagent are added along the edge of the test tube. The emergence of a white creamy precipitate signifies the existence of alkaloids.

B. Wagner's test: To 1 ml of plant extract, a few drops of Wagner's reagent are added along the walls of the test tube. The reddish-brown sediment verifies that the test result is positive.

Test for Amino Acid

A. Ninhydrin test: 2 drops of Ninhydrin solution are mixed with 1 ml of the plant extract. Look the presence of amino acids is indicated by a purple colour.

Test for Carbohydrate

A. Molish Test: Add drops of alcoholic α-naphthol solution to 1 ml of plant sample extract are included. The solution is thoroughly shaken, and several drops of concentrated sulfuric acid are added gently beside the edge of the test tube. A ring of violet colour signifies the existence of carbohydrates.

B. Benedict's test: Add 1 ml of Benedict's reagent to 1 ml of the filtrate. The blend is heated in a boiling water bath for 2 minutes. A precipitate with distinctive colour signifies the existence of sugar

Test for saturated oil and greases

A. Spot Test: A tiny amount of extract is placed between two filter papers, and any oil stain on the paper signifies the presence of fixed oils.

B. Saponification Test: A small amount of alcoholic potassium hydroxide solution is mixed with a tiny amount of extract combined with a drop of phenolphthalein. The solution is heated in a water bath for two hours. The production of soap or incomplete neutralization of alkali signifies the existence of solid oils and fats.

Test for Glycoside

A. Borntrager's Test: To 1 ml of plant extract, add 1 ml of chloroform and shake well. Separate the chloroform layer and then add a 10% ammonia solution to it. Pink color signifies the presence of glycoside.

B. Legal's test: 1 ml of plant extract is mixed with pyridine, followed by the addition of sodium nitroprusside solution, and then rendered alkaline with 10% NaOH. The presence of glycoside is shown by a pink colour.

Test for phytosterols

Salkowski's test: 1ml of the extract is mixed with 1ml of chloroform. Then, 1ml of concentrated sulfuric acid is added along the edge of the test tube.

A brown and reddish colour ring in the sulfuric acid layer indicates the presence of phytosterols.

Test for Protein

A Million Test: A few drops of million's reagent are added to 1 ml of plant extract. The formation of a white precipitate signifies the presence of protein.

B. Biuret Test: 2 ml of plant extract is mixed with 1 drop of 2% copper sulfate solution. Next, 1 ml of ethanol is added, along with an excess of potassium hydroxide pellets. A pink colour in the ethanolic layer signifies the presence of protein

Test for Saponins: Dilute the plant extract with distilled water to a total volume of 2 ml. Shake the suspension in a test tube for 15 minutes. A foam layer of two cm signifies the presence of saponins.

Test for Gum and Mucilage: Dissolve the extract in 1 ml of distilled water, then add 2 ml of absolute alcohol while stirring continuously.

Steroids Test: To qualitatively assess steroids, 1ml of the plant extract was collected. To these extracts, 1ml of chloroform solution was added, followed by the addition of 1ml of concentrated H2SO4 solution. The development of a vibrant yellow hue with green fluorescence signifies the presence of steroid precipitate.

Test for Terpenoids: To qualitatively identify terpenoids, 1ml of the plant extract was used. Add 1ml of chloroform and 0.5ml of concentrated solution to these extracts. H2SO4 incorporated. The development of a deep reddish-brown hue signals the presence of terpenoid precipitate.

Test for Tannins

A. Ferric chloride: The extract is mixed with 5ml of distilled water. To this, add a few drops of neutral 5% ferric chloride solution is added. A dark green colour signifies the presence of tannins.
B. Lead acetate Test: The extract is mixed with distilled water, and then 3ml of 10% lead acetate is added. A bulky white precipitate indicates the presence of tannins.

Test for Flavonoid

A. NaOH Test: Place 1ml of plant extract in two different test tubes. Add 1ml of NaOH to one of them. Tube and 1ml of distilled water in a separate tube. The presence of Flavonoids was verified by the emergence of yellow coloration. (Segaran *et al.,* 2019).

B. Lead acetate Test: The solution is prepared by dissolving the extract in distilled water, followed by the addition of 3ml of 10% lead acetate solution. A thick white precipitate signifies the existence of flavonoids.

Test for Anthraquinone Glycoside: In a test tube, 1ml of ammonia and 2ml of plant extract were combined and shaken thoroughly. The detection of anthraquinone was verified by the emergence of green colour at the bottom and reddish colour in the aqueous layer. (Segaran *et al.,* 2019).

Microorganisms for Testing

The bacterial species employed in this research were *Escherichia coli* and *Bacillus cereus*, while the fungal species used are *Aspergillus flavus* and *Aspergillus terreus*. Uncontaminated bacterial and fungal species

were acquired from the Microbiology Laboratory at Indira Priyadarshini College, Chhindwara, Madhya Pradesh. The bacteria were kept in nutrient broth (NB) at 37°C and fungus were maintained on Potato dextrose broth (PDB) at 28°C.

Antibacterial Activity

Antibacterial activity was conducted on four distinct extracts utilizing the agar well diffusion technique. Muller Hinton agar was utilized for the antibacterial susceptibility testing respectively. Using a micropipette, 100µl of bacterial culture was spread on a Muller Hinton Agar (Hi-media) plate with a sterile spreading tool. Afterward, wells with an 8 mm diameter were created in the medium utilizing a sterile cork borer. To the well, 100µl of various extracts were added accordingly. Wells filled with equal volumes of water, ethanol, and methanol acted as negative controls, whereas the standard antibiotic Tetracycline was utilized as the positive control. The plates were subsequently incubated vertically at 37° for 24 hours. The area of inhibition surrounding the well with leaf extract was noted and assessed following incubation.

Antifungal Activity

Antifungal testing was conducted on four distinct extracts utilizing the disc diffusion and agar well diffusion techniques. Sabouraud dextrose agar was utilized for antifungal susceptibility testing, respectively.

Disk diffusion technique

Plates of Sabouraud dextrose agar were made. Utilizing a micropipette, 100µl of fungal culture was distributed on an SDA plate using a sterile spreader. Sterile paper discs were loaded with crude extracts. The loaded disc was dried and positioned on the surface of the medium with sterile forceps, allowing the compound to diffuse for 5 minutes, after which the plates were incubated at 28°C for 72 hours. After the incubation period, the zones of inhibition that developed around the disk were measured using a transparent ruler in millimeters.

Agar Well Diffusion Method

It is also referred to as the plate hole diffusion method or the cup diffusion method. A micropipette was used to spread 100µl of fungal culture on an SDA plate with a sterile spreader. Afterward, wells with an 8 mm diameter were created in the medium utilizing a sterile cork borer. To the well, 100µl of various extracts were added accordingly. Wells with identical volumes of water, ethanol, and methanol acted as negative controls. The plates were subsequently incubated vertically at 25°-27° for 48 hours.

Results and Discussion

Morphological Characters of *Terminalia catappa L.*

The habits of *Terminalia catappa L.* along with its morphological features are illustrated in Fig. 1(A) and (B). *Terminalia catappa L.* is an upright, tall deciduous tree that grows to a height of 15-25 m, with a trunk diameter of 1-1.5 m, frequently having buttresses at its base. Spiral arrangements of nearly level, gently rising branches are located 1-2 m apart in layers or levels along the trunk. The pagoda-like structure fades as the branches lengthen and bend down at the ends. Bark brownish-gray, coarse due to age. The leaves of *Terminalia catappa L.* are obovate and alternate with short petioles, clustered spirally at the tips of branches, measuring 15-36 cm in length and 8-24 cm in width, dark green on top, lighter underneath, glossy and leathery (Jadhav *et al.,* 2015), with a smooth upper surface and hairs on the lower surface. Axillary inflorescence, spikes. The trees are monoecious, featuring separate male and female flowers on a single tree. Male flowers are located at the top and bisexual flowers at the bottom; male flowers are creamy, approximately 0.6 cm in diameter, without bracts, sessile, incomplete, unisexual, regular, actinomorphic, pentamerous, and epigynous. Sepals-5, aposepalous, campanulate, valvate, deciduous, petaloid (cream hue) superior. No petals present. Stamens 5+5, projecting outward, the upper 5 stamens alternate with calyx lobes, while the lower 5 stamens are opposite to calyx lobes; a disc is located at the base of the stamen, filaments are inwardly curved in bud, the anther is dithecous, yellow, introrse, dorsifixed, with longitudinal dehiscence, superior, Ovary missing, Bisexual flowers, ranging from creamy or white to greenish, approximately 0.6 cm in diameter, lacking bracts and bracteoles, sessile, incomplete, bisexual, regular, actinomorphic, pentamerous, and epigynous. Sepals (5), synsepalous, bell-shaped, valvate, petaloid (cream), superior, Petal-missing, Stamens 10, apostemonous, with unequal

filament lengths of approximately 0.3-0.4 cm, the anther is dithecous, introrse, dorsifixed, dehiscing longitudinally, and is superior (Zan, 2019).

Anatomical Characters of *Terminalia catappa L.*

Among the key anatomical aspects, the leaf and petiole structures offer a variety of traits that can be utilized for taxonomic applications, as illustrated in Fig. 2. In the surface view of Lamina, the epidermal cells on both surfaces exhibit a smooth cuticle and anticlinal walls while being wavy. Stomata are not found on the upper surface but are present on the lower surface. The stomata of the anomocytic type were observed on the lower surface (Zan, 2019).

The T.S. of the midrib (Fig.2c) exhibited a dorsiventral structure and a clear biconvex outline in the basal region, while in the apical region, it is plano-convex. The T.S. exhibited a single-layered epidermis topped with a thick cuticle. Epidermal cells on both the ventral and dorsal sides were rectangular, featuring notable thickening on the radial walls. A few epidermal cells on the ventral surfaces stretched out to create a layer of sharp trichomes. Underneath the epidermal cells on both sides, layers of collenchymatous cells were found; however, on the ventral side, they were broader with 3-4 layers of cells. After the collenchyma cells, 6–7 layers of parenchymatous cells with angular thickening were seen. Arc-shaped/Triangular vascular bundle displayed a layer of xylem encased by phloem on both sides of the xylem.

Xylem was made up of protoxylem and metaxylem. Metaxylem displayed elongated extensions of protoxylem on either side. Three air pockets were noted in the vascular strand's ring, featuring a large crystal situated in the pith area. Hairs were elongated from the outer layer of cells (Jadhav *et al.,* 2015)

The transverse section of the petiole illustrated in Fig. 2d reveals that the epidermal cells are parenchymatous, tightly packed, and oval to barrel-shaped. There are 2-4 layers of collenchyma above the vascular bundle, 5-6 layers of collenchyma above, and beneath the vascular bundle, 9-11 layers of polygonal parenchyma cells are arranged in a crescent shape and are collateral. A basic unicellular trichome exists. (Zan, 2019). Anatomical traits, along with various other traits, have been recognized as crucial in offering supplementary features that are usually of taxonomic importance in identifying and classifying plants.

Phytochemical Screening

The examination of biologically active compounds from the leaf extract of *T. catappa L.* was conducted following standard methods (Marathe *et al.,* 2022), with results displayed in Table-1 and Fig.5 (a, b, c, and d). The findings indicate the existence of flavonoids, alkaloids, steroids, tannins, saponins, phytosterol, anthraquinones, and glycosides.

The ethanolic extract was shown to possess carbohydrates, flavonoids, alongside alkaloids, phytosterols, and anthraquinones; however, amino acids, fixed oil and fat, glycosides, saponins, gum and mucilage, steroids, and terpenoids were not identified.

The cold water extract was found to contain alkaloids, tannins, fixed oils and fats, carbohydrates, phytosterols, saponins, steroids, flavonoids, and anthraquinones, while amino acids, glycosides, proteins, gum and mucilage, and terpenoids were not present. The hot water extract was identified to include flavonoids, alkaloids, carbohydrates, phytosterols, proteins, saponins, tannins, and anthraquinone, whereas amino acids, fixed oils and fats, glycosides, gums and mucilage, steroids, and terpenoids were not found.

The methanolic extract was determined to include alkaloids, phytosterols, amino acids, carbohydrates, fixed oil, fat, steroids, and tannins, whereas glycosides, proteins, saponins, terpenoids, and anthraquinones were not identified. Tannins have been shown to create irreversible complexes with proline-rich proteins, leading to the suppression of cellular protein synthesis. Flavonoids block nucleic acid production, affect cytoplasmic membrane activity, disrupt porin on the cell membrane, change membrane permeability, and reduce pathogenic potential. Quinines prevent the growth of microbes. Phenols interfere with protein synthesis in microorganisms. Glycosides lead to cell lysis and damage to the cytoplasmic membrane of microorganisms. The existence of these secondary metabolites has been noted to contribute to the antimicrobial activity exhibited by plants.

Antimicrobial Activity

The extract of *Terminalia catappa L.* tested for antibacterial and antifungal activity. This study utilized two bacterial cultures, *Bacillus cereus* and *Escherichia coli*, to evaluate the extract's efficacy.

Table.1 Phytochemical screening of different extract (ethanol, cold water, hot water, methanol) of *Terminalia catappa* L. leaves.

S. No	Test	Ethanol	Cold water	Hot water	Methanol
1	**Alkaloid**				
(a)	Mayers test	-	-	-	-
(b)	Wagners test	+	++	+	++
2	**Amino acid**				
(a)	Ninhydrin test	-	-	-	+
3	**Carbohydrate**				
(a)	Molish test	+	-	+	+
(b)	Benedict test	++	+	+	+
4	**Fixed oil and fat test**				
(a)	Spot test	-	+	-	+
(b)	Saponification test	-	-	-	-
5	**Glycosides test**				
(a)	Brontragers test	-	-	-	-
(b)	Legal test	-	-	+	-
6	**Phytosterol test**				
(a)	Solkowski test	+	+	+	++
7	**Protine test**				
(a)	Million test	+	-	+	-
(b)	Biuret test	-	-	+	-
8	**Saponins test**	-	+	+	-
9	**Gum and mucilage test**	-	-	-	-
10	**Steriods test**	-	+	-	+
11	**Terpenoids test**	-	-	-	-
12	**Tannins test**				
(a)	Ferric chloride	+	++	+	+
(b)	Lead acetate test	-	-	+	-
13	**Flavonids test**	++	+	++	+
(a)	Lead acetaite test	-	+	+	-
14	**Anthraqeinane Test**	+	+	+	-

(+)= Present in low quantity, (++) = Present in high quantity and (-) = Absent

Table.2 (A): *In vitro* antibacterial activity of different extracts of *Terminalia catappa L.* leaves by agar well diffusion method.

Extracts	Zone of inhibition (in mm)	
	Microorganisms	
	Escherichia coli	***Bacillus cereus***
Ethanol	16.33	17.66
Cold water	13.66	7.66
Hot water	12.66	6.33
Methanol	22.00	20.66
Tetracycline	29.66	41.66

Table.2 (B): *In vitro* antifungal activity of different extracts of *Terminalia catappa L.* leaves by Paper disc diffusion and Agar well diffusion method.

Extracts	Zone of inhibition (in mm)			
	Microorganisms			
	Aspergillus flavus		*Aspergillus terrus*	
	Paper disc diffusion	Agar well diffusion	Paper disc diffusion	Agar well diffusion
Ethanol	3	15	17	20
Cold water	11	8	12	8
Hot water	5	10	11	13
Methanol	7	10	4	21

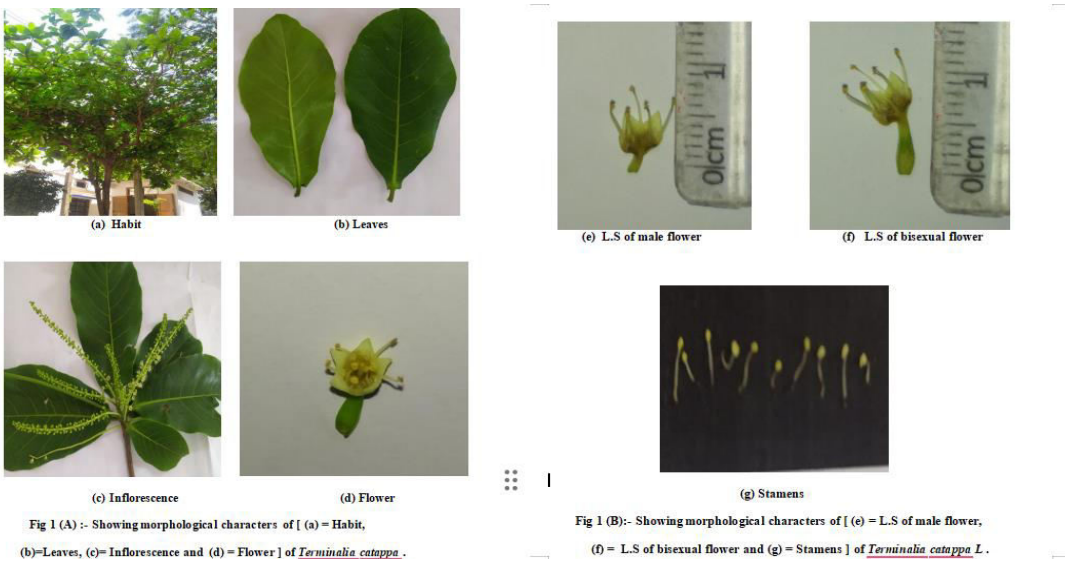

Fig 1 (A) :- Showing morphological characters of [(a) = Habit, (b)=Leaves, (c)= Inflorescence and (d) = Flower] of *Terminalia catappa* .

Fig 1 (B):- Showing morphological characters of [(e) = L.S of male flower, (f) = L.S of bisexual flower and (g) = Stamens] of *Terminalia catappa L* .

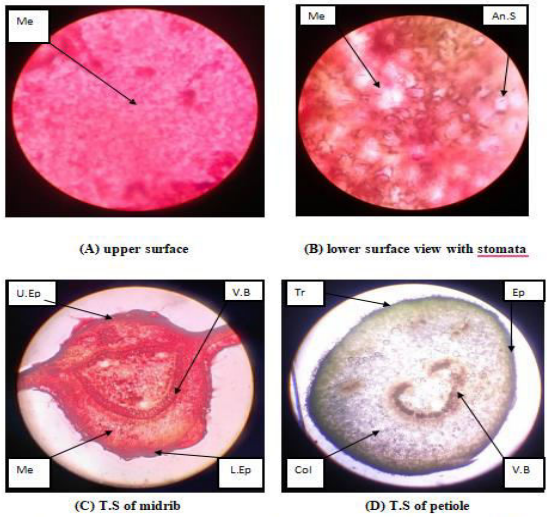

Fig. 2:- Showing anatomical characters of *Terminalia catappa L.* [Me = Mesophyll Cells, An.S = Anomocytic stomata , U.Ep = Upper epidermis , L.Ep = Lower epidermis,V.B = Vascular bundle ,Tr = Trichomes , Ep = Epidermis and Col= Collenchyma .]

Fig.3 :- Showing the antibacterial activity of *Terminalia catappa L* leaf extract against *Escherichia coli* and *Bacillus cereus* .[E = Ethanol extract , M=Methanol extract , H= Hot water extract and C=Cold water extract, Negative control = Pure solvents (ethanol, methanol, and Distilled water) and positive control = Tetracycline]

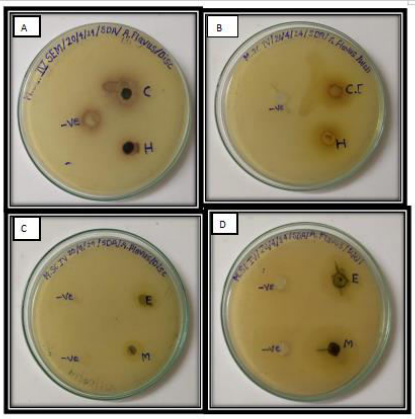

Fig 4 (A):- Showing antifungal activity of *Terminalia catappa* leaves against *Aspergillus flavus* by Paper disc diffusion (A and C) and Agar well diffusion method (B and D)[E = Ethanol Extract , M= Methanol extract, H= Hot water extract and C=Cold water extract, Negative control = Pure solvents (ethanol, methanol, and Distilled water)]

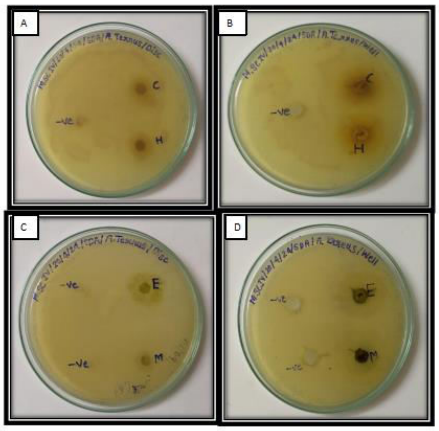

Fig 4 (B):- Showing antifungal activity of *Terminalia catappa* leaves against *Aspergillus terreus* by Paper disc diffusion (A and C) and Agar well diffusion method (B and D) E = Ethanol Extract , M= Methanol extract ,H= Hot water extract and C=Cold water extract, negative control = Pure solvents (ethanol, methanol, and Distilled water)

E. coli displayed the greatest inhibition with methanol extract at 22 mm, followed by ethanol at 16.33 mm, cold water at 13.66 mm, and the lowest with hot water at 12.66 mm. *Bacillus cereus* exhibited the highest inhibition zone with methanol at 20.66 mm, followed by water at 17.66 mm, cold water at 7.66 mm, and the least with hot water at 6.33 mm.

Cultures were evaluated using Tetracycline standard control, showing 41.66 mm for *Bacillus cereus* and 29.66 mm for *E. coli*, as indicated in Table 2 (A) and Fig. 3.

In this study, cultures of *Aspergillus flavus* and *Aspergillus terreus* were utilized to assess antifungal activity, which was evaluated using both disc and well diffusion methods. The cultures of *Aspergillus terreus* exhibited the greatest zone of inhibition (21 mm) for the methanol extract, followed by ethanol at 20 mm, hot water at 13 mm, and the least for cold water at 8 mm using the Agar well diffusion method.

While Disc Diffusion method shown highest zone of inhibition for ethanol 17 mm followed by cold water 12mm, then 11mm for hot water and least for methanol 4 mm. *Aspergillus flavus* exhibited the greatest zone of inhibition at 15 mm for ethanol, followed by 10 mm for both hot water and methanol, while the lowest was 8 mm for cold water using the agar well diffusion method. The Disc diffusion method displayed the greatest zone of

inhibition with cold water at 11 mm, followed by methanol at 7 mm, hot water at 5 mm, and the lowest with methanol at 3 mm as shown in Table 2 (B) and Fig. 4(a and b). The findings from both the Disc and well diffusion methods indicate that the well diffusion method is superior for antifungal research.

Harper and Cawston, 1945 found that the susceptibility of bacterial cultures to extract was assessed by measuring in these ranges: 0-7 mm indicates no activity; 8-12 mm indicates weak activity, while above 12 mm indicates strong activity.

The findings from this study demonstrate that methanolic extracts of *T. catappa* L displays considerable antimicrobial properties against all bacterial strains, possibly attributed to the presence of flavonoids, tannins, saponins, and steroids (Babayi *et al.,* 2004)

In developing nations, herbal medicine is frequently employed for the conventional management of health issues. In recent years, various drug-resistant human pathogenic microorganisms have emerged as a result of the unrestrained use of commercial antimicrobial medications frequently employed in treating infectious diseases (Kilani-Jaziri *et al.,* 2011). Besides this issue, antibiotics can also lead to negative effects on the host, such as hypersensitivity, immunosuppression, and allergic responses. Consequently, it is essential to create alternative antimicrobial medications for treating infections acquired from different sources, including medicinal plants (Yuen *et al.,* 2011). It is essential to discover new antimicrobials as microorganisms are becoming resistant to current antibiotics. The continual rise in multi-drug-resistant strains necessitate the quest for stronger new antibiotics. Therefore, there is a necessity for ongoing exploration of new effective and cost-efficient antimicrobial medications.

This research may enhance the comprehension of the function of phytochemicals in preventing the proliferation of pathogenic bacteria. The findings of the current study highlight the potential of *T. catappa L.* leaf as a source of therapeutic compounds that could contribute to the ongoing exploration for antimicrobial plants.

The anatomical characteristics of the petiole and leaf described in this study are quite significant in the generic delimitation and differentiation of the studied members within genus *Terminalia*. The Present study highlights that the extracts (ethanol, cold water,hot water and methanol) from *T.catappa L.* serves as a potential antibacterial agent against *Bacillus cereus* and *Escherichia coli* under *in vitro* condition. Among all the extracts, methaol extract showed the significant antibacterial activity. Thereby the study concluded that antibacterial activity of methanol extract of *T.catappa L.* and its active constituents may be helpful in interacting with various kinds of plant disease and human allergies. Antifungal activity was evaluated against cultures of *Aspergillus flavus* and *Aspergillus terreus* using both disc and well diffusion methods. Comparison of both the disc and well diffusion methods indicates that the well diffusion method is suitable for antifungal activity.

Further research could elucidate the possibilities of *T.catappa L.* in commercial use for the benefits of patients suffering from bacterial infections**.**

In conclusion methanolic leaf extracts of *T. catappa L.* showed significant antimicrobial activity against human pathogenic bacteria and presence of secondary metabolites responsible for antimicrobial action in the extracts. This suggests that constituents of the plant could be useful in drug.

From the findings of this study, the following recommendations could be made; Firstly, there is a need to further increase number of microorganism to study antibacterial and anti-fungal activity, secondly, it is necessary to isolate antimicrobial agent and determine toxicity of the active constituents and their side effects and third, it is necessary to do this work on big sample size and its effect on large on bacterial and fungal culture.

Author Contributions

AC conceived and designed the work and drafted the manuscript; AC and RK revising the work critically for important intellectual content and drafted the manuscript; AL was responsible for sample collection; AC and RK participated in all manipulations, and they analyzed and interpreted the results; All authors read and approved the final manuscript.

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Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

References

Babayi, H., Kolo, I., Okogun, J. I., and Ijah, U. J. J. (2004). The antimicrobial activities of methanolic extracts of Eucalyptus camalctulensis and Terminalia catappa against some pathogenic microorganisms.

Batiha, G.E. and Beshbishy, A.M. (2020). Gas chromatography-mass spectrometry analysis, phytochemical screening and anti-protozoal effects of the methanolic Viola tri color and acetonic Laurus nobilis extracts. BMC Complementary Medicine and Therapies, 20(87).

Chanda, S., Rakholiya, K., & Nair, R. (2011). Antimicrobial activity of Terminalia catappa L. leaf extracts against some clinically important pathogenic microbial strains. *Chinese Medicine*, *2*(04), 171.

Gangadher, A., Mohan, A., Jose, B. K., R., N. A., & S., S. (2023). Phytochemical analysis and antibacterial screening of Terminalia catappa against tetracycline resistant Escherichia coli. Journal of the Indian Veterinary Association, 21(2), 74–80.

Harper, G. J. Cawston, W. C. (1945): the in vitro determination of the sulphonamide sensitivity of bacteria. Journal of pathology and bacteriology. 57: 57-59.

Jadhav, S., Bhot, M., Barua, M., & Mandke, M. (2015). Comparative study of young and mature leaves of Terminalia catappa for evaluation of Physico-chemical, Pharmacognostical and Phytochemical analysis. *Int. J. of Life Sciences*, 12–20. research-article. Retrieved from http://www.ijlsci.in

Kilani-Jaziri, S., Bhouri, W., Skandrani, I., Limem, I., Chekir-Ghedira, L., & Ghedira, K. (2011). Phytochemical, antimicrobial, antioxidant and antigenotoxic potentials of Cyperus rotundus extracts. *South African Journal of Botany*, *77*(3), 767-776.

Lalam, R. (2019). Antimicrobial and phytochemical analysis of methanolic leaf extracts of Terminalia catappa against some human pathogenic bacteria. *Journal of Pharmacognosy and Phytochemistry*, *9*(1), 1200–1204. https://doi.org/10.22271/phyto.2020.v9.i1t.10621

Madhavan, K., Rukayadi, Y., & Mutalib, N. a. M. (2023). Phytochemical Constituents and Toxicity Analysis of Ethanolic Ketapang (Terminalia catappa L.) Leaf Extract. *Malaysian Applied Biology*, *52*(3), 105–114. https://doi.org/10.55230/mabjournal.v52i3.2685

Marathe, S. S., Sr., Masal, V. P., Pawar, S. A., & Dapoli Urban Bank Senior Science College. (2022, April). Studies on Qualitative Analysis of Some Phytochemicals of Terminalia Catappa L from Dapoli Tahsil (journal-article). *International Journal of Advanced Research in Science, Communication and Technology* (Vol. 2). IJARSCT. https://doi.org/10.48175/IJARSCT-3483

Oladeji, O.S., Odelade K.A., and Oloke, K. (2019). Phytochemical screening and anti-microbial investigation of Moringa oleifera leaf extract. African Journal of Science and Technology, Innovation, and Development, 12(1): 79-84

Praveena, K. (2014). Phytochemical, anti-microbial and *in-vitro* antioxidant activity of *Terminalia catappa*. *International Journal of Pharmacy and Life Sciences*, 5(2), 3325–3329.

Punwong. P., Juprasong. Y. and Traiperm, P.(2017) : Effects of an oil spill on the leaf anatomical characteristics of a beach plant. (Terminalia catappa L.) Environ Sci. Pollut. Res 24:21821-21828 https://doi.org/10.1007/s11356-017-9814-7.

Segaran, G., Dhevi, V. R., Shankar, S., & Ravi, L. (2019). Phytochemical profiles, in vitro antioxidant, anti-inflammatory and antibacterial activities of *Terminalia catappa*. *International Journal of Pharmaceutical Sciences Review and Research*, 55(2), 51–59.

Terças, A. G., De Souza Monteiro, A., Moffa, E. B., Santos, J. R. a. D., De Sousa, E. M., Pinto, A. R. B., De Andrade Monteiro, C. (2017). Phytochemical Characterization of Terminalia catappa Linn. Extracts and Their antifungal Activities against Candida spp. *Frontiers in Microbiology*, *8*, 595. https://doi.org/10.3389/fmicb.2017.00595

Yuen, M. K., Wong, R. W., Hägg, U., & Samaranayake, L. (2011). Antimicrobial activity of traditional Chinese medicines on common oral bacteria. *Chinese Medicine*, *2*(2), 37.

Yastanto, A. J., Indrati, R., & Department of Food and Agricultural Product Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada, Yogyakarta, Indonesia. (2024, June). Antimicrobial activity of Terminalia catappa L leaves in various colors (journal-article). *International Journal for Multidisciplinary Research (IJFMR)* (Vol. 6, pp. 1–3). Retrieved from https://www.ijfmr.com/papers/2024/4/25703.pdf

Zan, B. (2019). Study on morphology, anatomy and phytochemical test of *Terminalia catappa* L. leaves. *Myanmar Korea Conference Research Journal*, 3(1), 67–68.

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