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Investigation Into The Phytochemical Profiles And Antimicrobial Potential Of *Curcuma Caesia*, Indigenous To The Chhattisgarh Region Of India

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Abstract
Curcuma caesia is a medicinal plant and endowed with rich phytochemicals that find diverse application in treatment of various illness and dis-orders. The present paper reported the investigation of phytochemicals from the leaf, rhizome and modified root of Curcuma caesia and further evaluation of its antimicrobial activity. HPTLC analysis confirmed the presence of curcumin and turmerone in the plant extracts, with R_f values of 0.02 and 0.93 in leaves, 0.08 and 0.94 in rhizomes, and 0.01 and 0.92 in modified roots. Furthermore, FTIR spectroscopy revealed the existence of complex organic compounds in all three plant parts, characterized by functional groups such as aldehydes, phenols, and carboxylic groups. Additionally, the extracts' total phenol concentration was ascertained. The extracts were tested for antibacterial activity against a single pathogenic bacterium and fungal species, and antimicrobial potential was noted. The extracts' anti-oxidant activity was examined as well, and it was discovered that all of the sections utilized had proficient DPPH scavenging. The antioxidant efficacy of the plant can be attributed to its exceptionally high phenolic content, which is present in significant amounts in its extracts. Among the plant parts analyzed, the modified root demonstrated the most potent antioxidant activity (45 mg TAE/g), followed closely by the rhizome (38 mg TAE/g) and then the leaf (29 mg TAE/g).
Keywords: *Curcuma caesia, phytochemical constituents, HPTLC, FTIR, phenolic contents, Antimicrobial activity.*

1. INTRODUCTION

Chhattisgarh state is situated in India's east central region with north and south mountain lines. However, the soil underneath is quite fertile. The state is considered to have the third largest forest cover in India, inhabiting many medicinal herbs. These therapeutic herbs are essential to people's life of the forest inhabitants of Chhattisgarh. For this reason, these plants take place as an important part and related to many health evaluations and applications related to birth, old age, illness and death. Herbs have been considered valuable, effective and safe medicinal products since ancient times(1). The Indian and Chinese systems of Ayurvedic medicine indicate that herbs are useful as medicine(2). It is believed that up to 75,000 plant species, from lichens to trees, can cure various diseases(3). Act of the WHO, around 21,000 plants are used as a therapy in conventional medicine centers in rural areas. About 100 plant species are also used medicinally and come from India. This makes India a good source of medicinal plants in terms of quality and price, and in the second category in terms of exports. With 16 agroclimatic zones, it is also one of the 12 major biodiversity hubs in the world. Of the 45,000 plant species, 7,000 have been shown to be medicinal(4).

Herbal medicine's ongoing role in healthcare has profound international implications. As research accelerates, collaboration is vital for creating innovative treatments, especially in developing countries. Ancient Indian scriptures, such as the Rigveda, Atharvaveda, Charaka Samhita, and Sushruta Samhita, document the historical significance of herbal medicine(5). Plants are used medicinally because they contain a variety of significant phytochemicals, including reducing sugars, alkaloids, flavonoids, tannins, steroids, saponins, terpenes, and anthraquinones. Similar to other nations, traditional medicine finds extensive application in both rural and urban regions. The diversified population of India is comprised of speakers of many languages, cultures, and philosophical systems, contributing to the rich and varied practice and understanding of Ayurvedic science. Numerous studies have been published on the traditional applications of Indian medicinal plants in ethnobotany and ethnopharmacology(6).

Curcuma caesia, commonly referred to as black turmeric or *Kali haldi*, is a significant medicinal herb that is a member of the ginger family's genus. Black turmeric is a native of central and northeastern India. It is also found in Bangladesh as a wild species. Because of its therapeutic qualities, the black turmeric rhizome is highly important

commercially. Hemorrhoids, leprosy, pneumonia, asthma, cancer, epilepsy, heat stroke, postpartum toothache, and vomiting can all be treated using the rhizome of this plant. Because of the numerous human activities that have an impact on its natural environment, including the overuse of black turmeric for traditional medicinal uses, industrialization, urbanization, etc., this plant is currently regarded as a vulnerable species.The plant's rhizome is blue-black inside, and because essential oils are present, it has a distinct scent(7), (8). *Curcuma caesia* is extensively utilized in the herbal systems of Ayurveda, Unani, and Siddha. Additionally, it is advised for the treatment of cancer, excessive cholesterol, diabetes, eczema, psoriasis, wounds, menstrual irregularities, jaundice, inflammation, and blood purification. The rhizome of *Curcuma caesia* has historically been used for the remedy of various health issues, such as: bronchitis, hemorrhoids, asthma, tumors, and leukoplakia (9). The Khamti group, a collection of tribes known by that name in a specific region, utilized a new root treatment to keep snakes and scorpions from biting them. Tribes throughout India use fresh root decoction as anti-inflammatory medicine(10,11).

The healing power of therapeutic herbs is predicated on the phytochemical components found in plants that exert certain pharmacological effects on the body. In addition to the knowledge of determining the phytochemical components of medicinal plants, basic knowledge is also important for the development of drugs against various diseases(12). The classification of phytochemicals into primary and secondary groups depends on their metabolic utilization. The first level contains amino acids, proteins, sugars and chlorophyll, and the second level contains tannins, saponins, alkaloids, phenols, flavonoids, etc. (13). The main components in medicinal plants can be extracted using a variety of techniques, mostly solvents. Plant phytochemicals are extracted using a variety of solvents, including water, methanol, and petroleum ether. The extraction, purification, characterization, and use of several *Curcuma caesia* parts are presented in this work.

2. Materials and Methods

2.1 Sample

The underground stems (rhizomes) of *Curcuma caesia* were collected from the Bioresource Complex of Government V.Y.T. PG. Autonomous College in Durg, Chhattisgarh, India (Pin code: 491001) and were preserved for subsequent research investigations.

2.2 Sample Processing

At the harvesting stage, approximately 6 months after maturity, the rhizomes of *Curcuma caesia* were thoroughly washed to remove soil and debris, then carefully dried. Subsequently, the dried plant materialsincluding leaves, rhizomes, and modified roots were individually ground into fine powder using an electric grinder and stored in labeled polyethylene containers for preservation.

2.3 Extraction

A 10-gram sample of *Curcuma caesia* rhizome powder was individually extracted using three solvents: distilled water, methanol, and petroleum ether. Each mixture underwent a standardized extraction process, involving heat sterilization at 50°C for 30 minutes, followed by filtration and centrifugation at 2500 RPM for 20 minutes. The resulting extracts were subsequently air-dried and securely stored in labeled containers, maintained at a consistent temperature range of 4-8°C to preserve their chemical integrity.

2.4 Qualitative analysis for Phytochemicals

The phytochemicals from crude extract were determined followingwith slight modification of the protocols suggested byEjikeme(14).

2.4.1 Test for Tannins

A 0.30-gram sample of *Curcuma caesia* extract was heated in 30 ml of water for 10 minutes and subsequently filtered through Whatman No. 42 filter paper. Upon introducing 3 drops of 0.1% ferric chloride solution to the filtrate, a distinctive color transformation to blue-black or brownish-green was observed, which served as a qualitative indication of the presence of phenolic compounds.

2.4.2 Test for Saponin

A 0.30g powdered sample was combined with 30ml of distilled water and heated for 10 minutes, followed by filtration. Three drops of olive oil were then introduced to the filtrate, maintaining a 10:5 water ratio. Upon gentle agitation, a stable foam formation was detected, indicating a specific characteristic of the sample.

2.4.3 Test for Terpenoids

A 0.30g plant powder sample was subjected to an extended boiling process in 30 ml of distilled water for 2 hours. Following extraction, 5 ml of the extract was carefully layered with concentrated sulfuric acid and chloroform. A characteristic reddish-brown coloration at the interface confirmed the presence of terpenoids.

2.4.4 Test for Flavonoids

A 0.30g sample was placed on Whatman No. 42 filter paper (125 mm diameter) and extracted by soaking in 30 ml of deionized water for two hours. Ten milliliters of the aqueous filtrate were mixed with 5 ml of concentrated sulfuric acid and 5% diluted ammonia solution. The transient appearance of a golden hue, which faded upon standing, was characteristic of flavonoid presence.

2.4.5 Test for Alkaloids

2-grams of powdered sample were briefly boiled for 2 minutes and then filtered through a 125 mm Whatman No. 42 filter paper to obtain the extract. The filtrate was then alkalized by adding 5 ml of 28% ammonia solution (NH_3) in a separating funnel. A secondary extraction was conducted using 5.0 ml of 1.0M diluted sulfuric acid and chloroform. Subsequently, 2 ml of the acid extract was combined with Dragendorff's reagent, and the resulting orange coloration confirmed the presence of alkaloids (based on the bismuth potassium iodide solution test).

2.4.6 Test for Glycoside

2-gram samples were heated in a water bath for 5 minutes and subsequently filtered using Gem filter paper (12.5 cm in diameter). The obtained filtrate underwent further analytical testing: 0.2 ml of Fehling's A and B solutions were mixed with 5 cm* of the filtrate, creating an alkaline solution (verified by litmus paper). Water was replaced with 15 ml of 1.0 M sulfuric acid, and the resulting precipitate was quantitatively assessed. After heating, a characteristic brick-red coloration indicated a positive test result, with the precipitate volume suggesting the potential presence of glycosides.

2.5 Confirmation of phytochemicals

2.5.1 FTIR spectroscopy

Fourier Transform Infrared Spectroscopy (FTIR) is significant for analyzing *Curcuma caesia* (Black Turmeric) extract because it helps identify its functional groups and chemical composition.FTIR detects characteristic functional groups (like hydroxyl, carbonyl, alkaloids, and phenolics) in the extract, which are responsible for its medicinal properties.FTIR spectra reveal molecular vibrations that provide insights into the chemical structure of active compounds like curcuminoids, flavonoids, and essential oils.Thermo Nicolet Avtar 370 FTIR spectrophotometer was used to record FTIR spectra in order to validate the existence of typical functional groups. KBr pellet was used to create samples in the approximate range of 500–4000 cm^{-1}.

2.5.2 HPTLC

The HPTLC analysis was conducted using a comprehensive CAMAG system, including an automated TLC sampler, dual-chamber development chamber, Cats-3 software, and a 25 µL HPTLC syringe. Curcuma caesia extract was applied to pre-coated silica gel aluminum HPTLC plates (SG60 F254, 20 cm x 10 cm, 0.02 mm thickness, Merck, Germany) using consistent parameters: 0.1 µL/sec application rate, 5 mm band gap, and 5 mm × 0.45 mm sample size. Chromatographic development occurred in a saturated glass chamber using a mobile phase of n-hexane and ethyl acetate (9.8:0.2 v/v), with optimal conditions of 30 minutes saturation time, 25°C±2 temperature, and 60%±5 relative humidity. The developed plate was air-dried and scanned using a CAMAG TLC Scanner-III at 254 nm in reflection-absorbance mode, with a scan speed of 10 mm/s and 20 nm monochromatic bandwidth. Deuterium light provided UV spectrum analysis between 190-400 nm. This meticulous process, including triple-checking of traces and baseline correction, ensured accurate and reliable HPTLC analysis of the *Curcuma caesia* extract.

Calibration curves for standards: Initial standard solutions (50 mg/ml) were made in acetonitrile. A 1 ml portion was transferred to a 10 ml flask and brought to volume with acetonitrile. Subsequent dilutions yielded calibration standards with concentrations spanning 0.1-0.6 mg/ml.

2.6 Quantitative Analysis for total phenolic contents (TPC)

The phenol content in the plant extracts was quantified using the Folin-Ciocalteu (FC) reagent method, as described by Barapatre(15). The procedure involved mixing 1 mg/ml of plant extract solution with 0.5 ml of 10% FC reagent and 2 ml of 2% w/v Na_2CO_3. This mixture was agitated and incubated at 45°C for 15 minutes, after

which absorbance was measured at 765 nm using a UV spectrophotometer. Results were expressed as milligrams of gallic acid equivalent (GAE) per µg/mg of extract.

To assess the reducing power of the turmeric extract, concentrations ranging from 2.5 to 15 mg/ml were prepared in methanol. These solutions were combined with phosphate buffer (0.2 M, pH 6.6) and potassium ferricyanide (1%), then incubated at room temperature for 20 minutes. Following the addition of 10% TCA, the mixture was centrifuged at 3,000 X g for 10 minutes. The supernatant was then mixed with distilled water and 1% ferric chloride. The absorbance of this final solution was measured at 700 nm, with an increase in absorbance indicating a higher reducing power of the extract. This method provides a comprehensive evaluation of the phenolic content and reducing capacity of the turmeric extract(16).

2.7 Anti-oxidant analysisby2, 2-diphenyl-1-picrylhydrazyl Radical Scavenging Assay

The rhizome extracts' antibacterial and antioxidant properties were assessed using a modified method based on Ebrahimabadi's technique(17). The antioxidant activity of the extracts was evaluated using the DPPH radical scavenging assay. Briefly, 3 ml of 40 mg/L DPPH solution in methanol was mixed with the extracts and incubated in the dark at room temperature for 30 minutes. The absorbance of the resulting solutions was measured at 517 nm using a UV-VIS spectrophotometer. Ascorbic acid and BHT were used as positive controls, while a DPPH methanol solution served as a negative control. Additionally, extract-only solutions (without DPPH) were used as negative controls for the plant extracts. The percentage of DPPH radical inhibition was calculated using the formula.

$$I\ \% = \frac{(A_{control} - A_{sample})}{(A_{control})} \times 100$$

Where $A_{control}$ and A_{sample} are the absorbances of the control and test samples, respectively.

2.8 Antimicrobial analysis

2.8.1 Antibacterial

The obtained Escherichia coli (NCIM 2065) was kept at 4°C after being subcultured on nutritive agar medium (NAM). For a whole day, the microorganisms employed in the antibacterial activity test were cultured. Using the well diffusion technique on NAM, the antibacterial properties of each plant extract were examined. The zone of inhibition (ZOI) around the well perimeter was measured at the millimetre scale.

2.8.2 Antifungal

The obtained Fusarium was kept at 4°C after being subcultured on Potato Dextrose Agar Medium (PDA). For 48 hours, the microorganisms employed in the antifungal activity test were cultivated. Using the well diffusion technique on PDA, the antifungal properties of each plant extract were examined. The zone of inhibition (ZOI) around the well perimeter was measured at the millimetre scale.

3. RESULTS

3.1 Phytochemical analysis

The phytochemical analysis is the initial step in analyzing the useful secondary metabolites in the sample. The qualitative analysis of different parts of *Curcuma caesia* is depicted in Table 1. It was observed that all parts of *Curcuma caesia* used for study was having tannins, saponin, terpenoids, flavonoids, alkaloids and glycoside contents in their water, methanolic extract. Petroleum ether was found suitable solvent for saponin and terpenoids only. The extraction solvents yielded varied phytochemical spectra due to their different polarities. The leaf extract had flavonoids, tannins, alkaloids,curcuminoids, terpenoids, and steroids were found in the rhizome extracts, exhibiting therapeutic effects, antimicrobia activities.

Table 1: Qualitative analysis of phytochemicalsin different parts ofCurcuma caesia.

		Leaf	**Rhizome**	**Modified Root**

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Sl. No	Phytochemical	Water	Methanol	Petroleum ether	Water	Methanol	Petroleum ether	Water	Methanol	Petroleum ether
1.	Tannins	+	+	-	+	+	-	+	+	-
2.	Saponin	+	+	+	+	+	+	+	+	+
3.	Terpenoids	+	+	+	+	+	+	+	+	+
4.	Flavonoids	+	+	-	+	+	-	+	+	-
5.	Alkaloids	+	+	-	+	+	-	+	+	-
6.	Glycoside	+	+	-	+	+	-	+	+	-

3.1 FTIR analysis

FTIR analysis of *Curcuma caesia* extracts has shown the presence of many functional groups, including phenols and aldehydes.

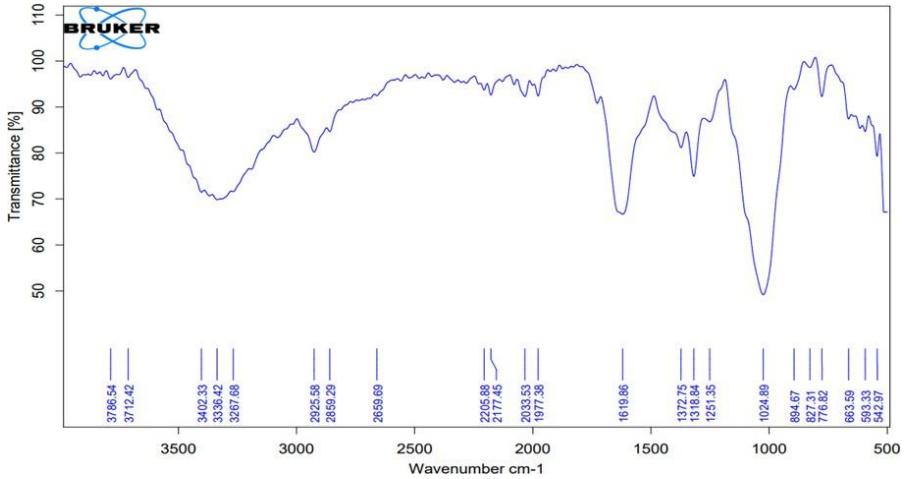

Figure 1: FTIR spectraof leaf extract of Curcuma caesia

Figure 1 displays the FTIR spectra of *Curcuma caesia* leaves at wavenumber between 500 and 4000 cm^{-1} obtained using the KBr pellet method. The graphic displays the peaks at various wavenumber ranges. The characteristic peaks were observed at 3267.68, which showed the O-H stretch and the H-bond; at 1619.66, the C-C stretch in the ring; at 1640.86, the C-C stretch in the ring; at 1750.08, the C=O stretch; at 1251, 1024, the C-O stretch; and at 894.67 and 827.31, the bending of =C-H. This demonstrates that *Curcuma caesia* contains functional groups including phenol, aldehydes, and carboxylic groups.

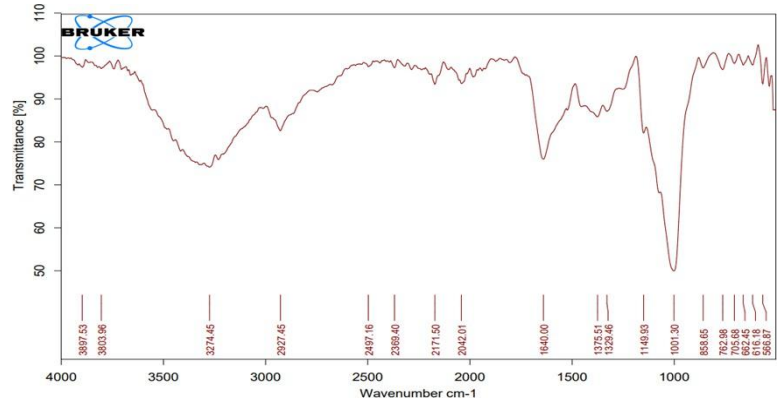

Figure 2: FTIRspectra of rhizome extract of Curcuma caesia

Figure 2 displays the FTIR spectra of *Curcuma caesia* rhizome at wavenumber ranging from 500 to 4000 cm^{-1}, obtained using the KBr pellet method. The picture displays the peaks at various wavenumber ranges. The FTIR spectrum exhibited absorption peaks indicative of: O-H stretching/H-bonding (3247.90 cm^{-1}), aromatic ring C-C stretching (1596.16, 1640.86 cm^{-1}), C=O stretching (1760.08 cm^{-1}), C-O stretching (1116, 1070 cm^{-1}), and =C-H bending vibrations (991.45, 917.19 cm^{-1}). This demonstrates that *Curcuma caesia's* rhizome contains functional groups such carboxylic groups, phenols, and aldehydes.

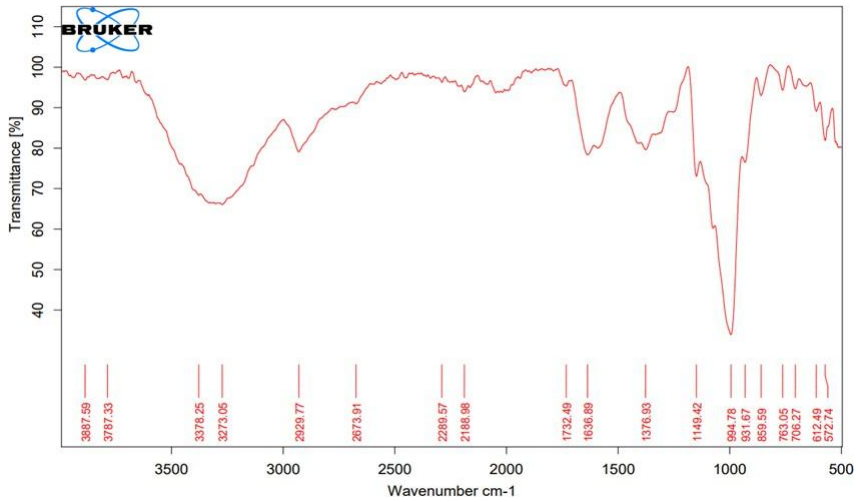

Figure 3: FTIR spectra of modified root extract of Curcuma caesia

Figure 3 displays the FTIR spectra of the modified root of *Curcuma caesia* at wavenumbers between 500 and 4000 cm^{-1} obtained using the KBr pellet method. The graphic displays the peaks at various wavenumber ranges. The FTIR spectrum exhibited absorption peaks indicative of the following functional groups: hydroxyl (O-H) and hydrogen bonding (3378.90 cm^{-1}), aromatic ring C-C stretching (1439.39, 1636.39 cm^{-1}), C=O stretching (1732.49 cm^{-1}), C-O stretching (1149.42, 994.78 cm^{-1}), and =C-H bending (931.67, 859.59 cm^{-1}). This demonstrates that the modified root of *Curcuma caesia* contains functional groups such carboxylic groups, phenols, and aldehydes.

3.4 HPTLC analysis

The HPTLC analysis of the rhizome of *Curcuma caesia* revealed the presence of four bioactive components, while the analysis of the modified root showed the presence of two bioactive components. Among these, both curcumin and ar-turmerone were clearly detected in all parts of *Curcuma caesia*, including the leaf, rhizome, and modified root. Figures 4, 5, and 6 illustrate the presence of bioactive constituents in the leaf, rhizome, and modified root, respectively. The Rf values of the bands, serving as reference points for curcumin and Ar-turmerone, are 0.38 and 0.5 ± 0.06, respectively(25), (26).The HPTLC analysis of leaf of *Curcuma caesia* showed a noticeable peak at around 0.6 ± 0.05 which confirms the presence of Camphor (27). The other Rf values seen at 0.02, 0.93 in leaf, 0.08, 0.94 in rhizome and 0.01, 0.92 in modified root exhibited the presence of anti-oxidants. *Curcuma caesia*is reported to possess around 97.5 % oil. This oil is composed of various constituents such as 28.3 % Camphor, 12.3% Ar-turmerone, 8.2% (Z)-Ocimene, 6.8% 1-ar-curcumene, 5.3% 1, 8-Cineole (5.3 %), 4.8% Elemene, 4.4% borneol, 3.3% bornyl acetate and 2.82% Curcumin as the main constituents. Another study reported Linalool also to be the main component having composition around 20.42%, this was preceded by 15.66% Ocimene, 14.84% 1-Ar-curcumene, 12.60%zingiberol (12.60), 9% 1,8-cineole (9.06 %), and 7.4% borneol as the main components (28,29).

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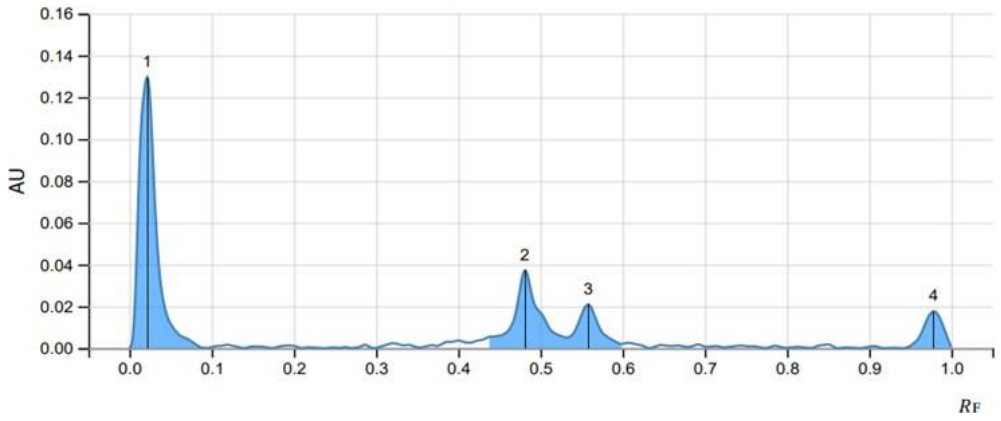

Figure 4: HPTLCspectrumof leaf extract of Curcuma caesia

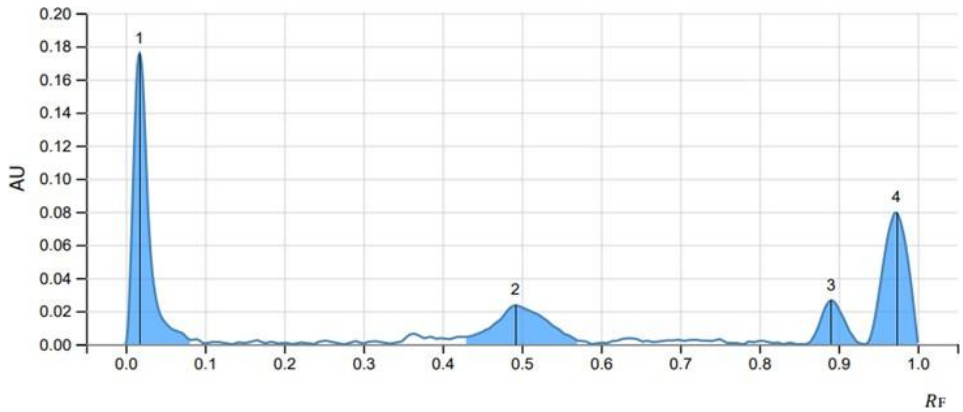

Figure 5: HPTLCspectrum of rhizome extract of Curcuma caesia

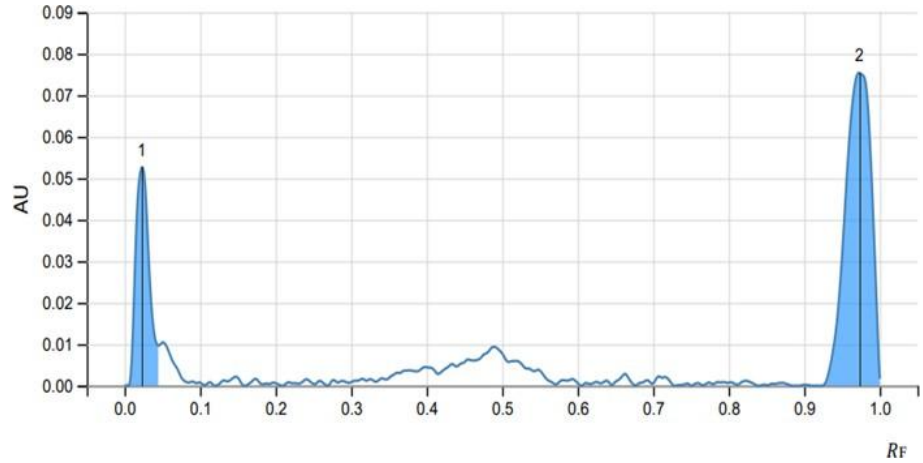

Figure6: HPTLCspectrum of modified rootextract of Curcuma caesia

3.5 Determination of total phenols

Folin-Ciocalteu's assay determined the total phenolic content in *Curcuma caesia* extracts, yielding values of 38 mg TAE/g (leaf) and 45 mg TAE/g (rhizome), indicating higher phenolic content in rhizomes. The variation can be attributed as different parts of plant has different number of phytochemicals, as a result of different constituents and based on the kind of phenolics present in particular part(30).

The phenols are accountable for antioxidant activity therefore measuring the quantity of phenols present can be relatable to their antioxidant properties(31). Therefore, in the following study we have noted a sensible reducing power with both the rhizome and leaves and can be seen from Figure 7.

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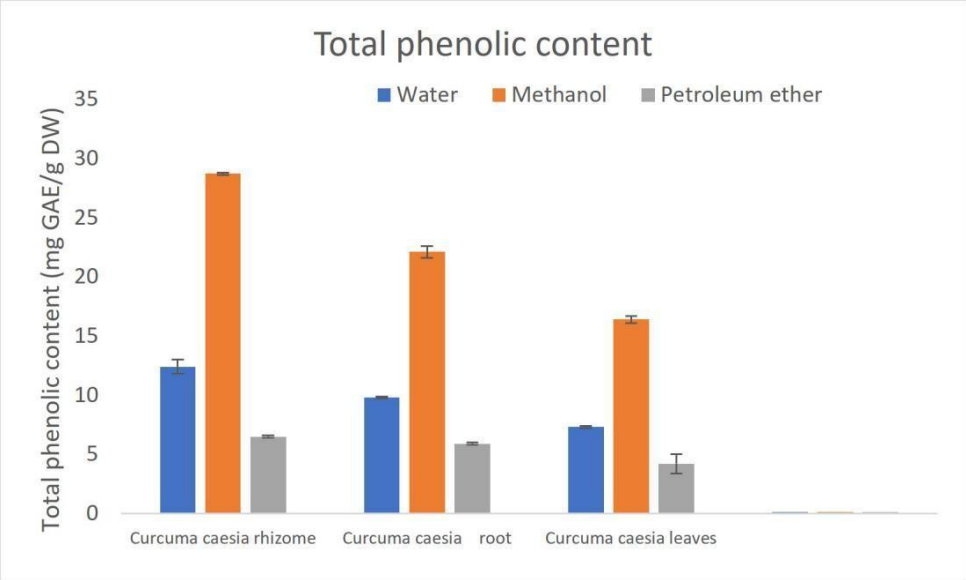

Figure 7: Reducing power of total phenolics of leaf and rhizome and root of Curcuma caesia with different solvents

The reducing power of aqueous, methanolic and petroleum ether extracts of leaf rhizome and modified root samples were examined in Figure 7. Reducing power is frequently employed as a measure of electron-donating activity that approaches plant extracts' antioxidative qualities. It was observed that, all three parts of *Curcuma caesia* exhibit reducing power in terms of ascorbic acid equivalent. The methanolic extract was found superior among the others.

3.6 Determination of Antioxidant Activity by DPPH Radical Scavenging Method

Curcuma caesia's modified roots have the ability to scavenge superoxide molecules. In a similar way, *Curcuma caesia* extract's capacity to scavenge free radicals was also examined and found to be greater. Given that phenolics are a key component of both the *Curcuma caesia* rhizome and leaves, it is possible that their presence contributes to their capacity to scavenge free radicals. *Curcuma caesia* was leaves and rhizome contain flavonoids, which are responsible for the plant's antioxidant properties. Plant extracts also have extensive anti-superoxide capabilities due to their diverse replacements of free hydroxyls.

3.7 Microbiological investigations

3.7.1 Antibacterial Activity

The antibacterial analysis of leaf, rhizome and modified roots of *Curcuma caesia* was done against potential human pathogenic gram-negative bacteria(Figure 8). The bacterial pathogen *E. coli* is known for production of shiga toxin resulting illness including bloody diarrhea, fever, abdominal cramps, nausea and vomiting.

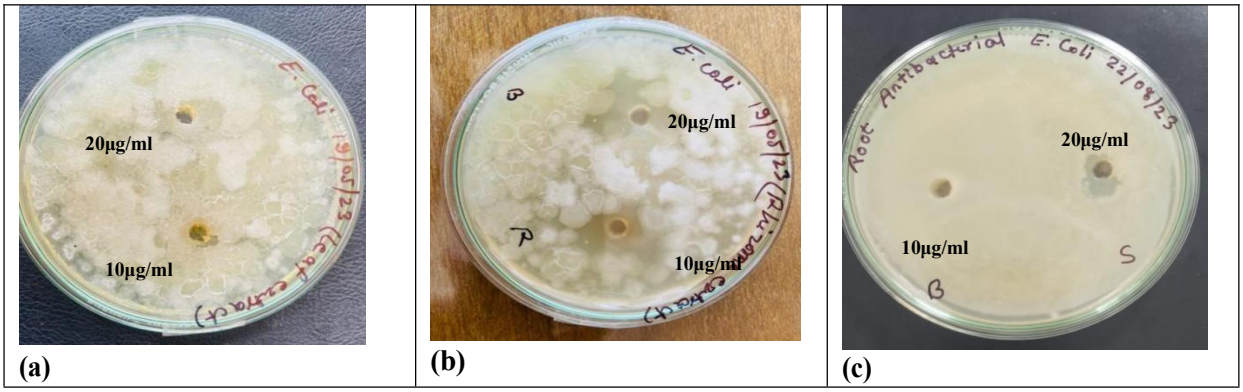

Figure 8: Antibacterial of(a) leave extract (b) rhizome extract (c) modified root extractof*Curcuma caesia*against *E. Coli*

Table2: Zones of inhibition (ZOIs) of antibacterial activity for Curcuma caesia (10, and 20 µg/mL) with different concentrations

Bacteria	Leave extract		Rhizome extract		Modified root extract	
	10 µg/ml	**20 µg/ml**	**10 µg/ml**	**20 µg/ml**	**10 µg/ml**	**20 µg/ml**
E. coli	4	7	5	9	3	5

The results revealed differing levels of antibacterial activity among the tested extracts against *E. coli* (Table 2). The rhizome extract demonstrated the highest activity against E. coli inhibition, displaying zones of 5 mm and 9 mm at concentrations of 10 µg/ml and 20 µg/ml, respectively. Following closely, the leaf extract exhibited inhibition zones of 4 mm and 7 mm, while the modified root extract displayed the least activity, with zones of 3 mm and 5 mm.

3.7.2 Antifungal Activity

Curcuma caesia extracts exhibited notable antifungal efficacy against *Fusarium*species(Figure 10), which are responsible for a range of human infections. These findings suggest that plant-derived antifungals may offer a safer, effective treatment option with reduced side effects compared to conventional synthetic antifungals.

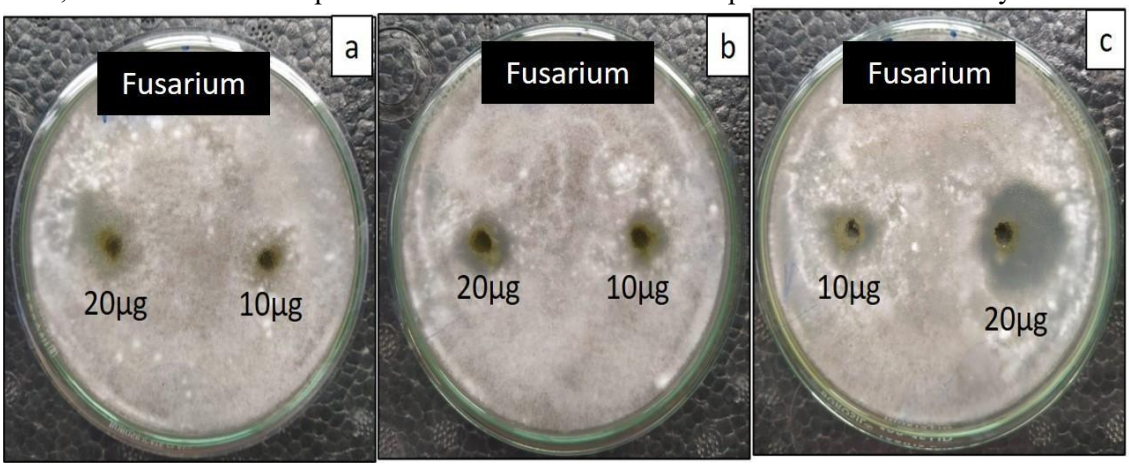

Figure 10: Antifungal activity of(a) leave extract (b) rhizome extract (c) modified root extract of *Curcuma caesia*against*Fusarium*

Table3: Zones of inhibition (ZOIs) of antifungal activity for Curcuma caesia(10, and 20 µg/mL) with different concentrations

Fungi	Leave extract		Rhizome extract		Modified root extract	
	10 µg/ml	**20 µg/ml**	**10 µg/ml**	**20 µg/ml**	**10 µg/ml**	**20 µg/ml**
Fusarium	6mm	12mm	6mm	10mm	7mm	10mm

The results indicate varying degrees of antifungal activity among the different extracts tested against *Fusarium* (Table 3). For *Fusarium* inhibition, the leave extract displayed the most potent inhibition, yielding zones of 6 mm and 12 mm at 10 µg/ml and 20 µg/ml concentrations. The rhizome and modified root extracts also exhibited notable activity against *Fusarium*, with zones ranging from 6 mm to 10 mm.

DISCUSSION

Black turmeric, scientifically known as Curcuma caesia, is a unique and scarce type of turmeric found in the Indian subcontinent. Unlike regular turmeric, it has a stunning dark purplish-black colour. This perennial herb belongs to the ginger family and is usually found in forested areas with fertile and moist soil(18). With large lance-shaped leaves, it grows up to 2-3 feet tall. Black turmeric it has been cherished in Ayurvedic and traditional medicine for its anti-inflammatory, antioxidant, and antimicrobial properties. It is applied in different formulations to combat respiratory disorders, digestive troubles, and skin conditions also. Apart from its medicinal properties, it also holds cultural significance and is occasionally utilized in religious ceremonies. However, it is not as readily accessible or cultivated as common turmeric variants due to its rarity and specific growth requirements.

The phytochemical analysis is the initial step in analyzing the useful secondary metabolites in the sample.The leaf extract had flavonoids, tannins, and alkaloids, which contribute to antioxidant and anti-inflammatory properties. Curcuminoids, terpenoids, and steroids were found in the rhizome extracts, exhibiting therapeutic effects, antimicrobial and hepatoprotective activities. The modified root extract contained phenolics, saponins, and glycosides, with potential pharmacological significance in treating various ailments. This analysis provides valuable insights into the medicinal potential and chemical diversity of Curcuma caesia, facilitating further exploration in pharmacology and drug development(20). Additionally, water solubility of key phytochemicals facilitates their broad applicability in various fields.

FTIR analysis of *Curcuma caesia* extracts has shown the presence of many functional groups, such carboxylic groups, phenols, and aldehydes.According to McLaren and Turkington, these functional groups were consistently found in leaves, rhizomes, and modified roots, indicating a constant chemical composition throughout the plant. This homogeneity suggests that the chemical contents are comparable, which may have something to do with the biological processes or metabolic pathways of the plant(23).*Curcuma caesia* may contain bioactive chemicals because of the existence of these particular functional groups, which are recognized for their pharmacological and therapeutic qualities. The plant may have medicinal potential because of phenolic chemicals, which are known for their antioxidant qualities, as well as aldehydes and carboxylic groups, which are frequently present in bioactive molecules(24).

The HPTLC analysis of leaf, rhizome and roots of *Curcuma caesia* showed the presence of bioactive compounds respectively figure 4, 5, 6 among these, the presence of constituents of Curcumin and Turmerone are clearly seen in all the parts. Comparing with R_f values of the standard for reference as curcumin and tumerone at 0.38 and 0.5 respectively(25).

Folin-Ciocalteu's assay determined the total phenolic content in Curcuma caesia extracts, indicating higher phenolic content in rhizomes. The variation can be attributed as different parts of plant has different number of phytochemicals, as a result of different constituents and based on the kind of phenolics present in particular part(30).

The study revealed that all extracts exhibited concentration-dependent DPPH radical scavenging activity. The extract concentration and the DPPH radical scavenging activity showed a nonlinear relationship. The extracts with the highest activity were methanolic and ethanolic. The available concentrations linked to the molecular structures of a given chemical determine its antioxidant activity. As the concentration of extract increases, so does the number of active groups involved in radical scavenging inside a single molecule

The antibacterial analysis of leaf, rhizome and modified roots of *Curcuma caesia* was done against potential human pathogenic gram-negative bacteria. The extracts exhibited substantial antibacterial efficacy against Gram-negative bacteria, validating the traditional uses of the plant. The phytochemicals present in the extracts were responsible for this activity, underscoring the medicinal value of local plants for future pharmaceutical applications.The rhizome extract demonstrated the highest activity against E. coli inhibition, displaying zones of 5 mm and 9 mm at concentrations of 10 µg/ml and 20 µg/ml, respectively. Following closely, the leaf extract exhibited inhibition zones of 4 mm and 7 mm, while the modified root extract displayed the least activity, with zones of 3 mm and 5 mm. These findings highlight the varying effectiveness of the extracts against bacterial pathogens. Further exploration into their mechanisms of action and potential applications is warranted.

Antifungal efficacy against *Fusarium* specieswhich are responsible for a range of human infections.The rhizome and modified root extracts also exhibited notable activity against *Fusarium*, with zones ranging from 6 mm to 10 mm. These findings suggest that the plant extracts, particularly the rhizome and leave extracts, hold promise as

potential antifungal agents, with differing effectiveness against bacterial and fungal pathogens. Further investigation into their mechanisms of action and potential applications is warranted.

CONCLUSION

The present studyhas focused on the phytochemical constituents of *Curcuma caesia*. It was seen that the plant possesses many phytochemicals which are beneficial. It has investigated the functional groups present in the leaf, rhizome and modified root of the plant. A detailed investigation on the antimicrobial activity using *E. Coli* and fungi *Fusarium* demonstrated the plant to have exceptional antimicrobial activity which makes it highly beneficial for medical use. The phytochemical constituents of the plants were further confirmed by HPTCL analysis. The HPTLC is seen to be highly reliable, simple and rapid authentic procedure; on comparing the obtained data with standard references it has confirmed the presence of various phytochemicals and antioxidants in the leaves, rhizome and modified root of *Curcuma caesia.*In conclusion, FTIR analysis underscores the chemical complexity of *Curcuma caesia* and offers initial insights into its potential bioactive components.*Curcuma caesia*leaf, rhizome, and modified root have notably high total phenol content and antioxidant activity. The plant's antioxidant action is attributed to its high phenolic content, which is seen in the plant extracts. The ethanolic extract's DPPH scavenging activity (%) was found to be 87% higher than that of the methanolic (82%), and aqueous 70%.

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