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COMPARATIVE EVALUATION OF ANTIOXIDANT AND ANTIBACTERIAL ACTIVITIES OF METHANOLIC AND ETHANOLIC LEAVE AND RHIZOME EXTRACTS OF *CURCUMA CAESIA ROXB.* AND *CURCUMA LONGA L.*

Shradha Wankhade[1], Shaifali Mathur*[2]

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***Corresponding Author: Shaifali Mathur**
Faculty of Life science (Biotechnology), Shri Shankaracharya Professional University, Bhilai, Chhatisgarh.
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ABSTRACT
The increasing prevalence of antimicrobial resistance and oxidative stress-related disorders has stimulated the search for effective natural bioactive compounds from medicinal plants. The present study aimed to comparatively evaluate the antibacterial and antioxidant potential of methanolic and ethanolic extracts of leaves and rhizomes of *Curcuma caesia roxb.* and *Curcuma longa L.* Fresh plant materials were shade-dried, powdered, and extracted using methanol and ethanol through maceration. Antibacterial activity was assessed against *Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Klebsiella pneumoniae* using the agar well diffusion method, while antioxidant activity was determined by the DPPH free radical scavenging assay.All extracts exhibited varying degrees of antibacterial and antioxidant activities. Among the tested samples, the methanolic rhizome extract of *Curcuma caesia roxb.* demonstrated the strongest antibacterial activity, producing inhibition zones of 18.53 ± 0.20 mm against *E. coli*, 21.27 ± 0.32 mm against *S. aureus*, 15.87 ± 0.18 mm against *P. aeruginosa*, and 19.43 ± 0.20 mm against *K. pneumoniae*. Methanolic extracts generally exhibited higher antibacterial activity than ethanolic extracts, while rhizome extracts were more effective than leaf extracts. The DPPH assay revealed concentration-dependent antioxidant activity for all extracts. The methanolic rhizome extract of *Curcuma caesia roxb.* exhibited the strongest antioxidant activity among the plant samples, with 86.27 ± 0.58% inhibition at 300 µg/ml and an IC_{50} value of 104.5 ± 3.5 µg/ml. Antioxidant activity followed the order: Ascorbic Acid > CCR(M) > CCR(E) > CLR(M) > CCL(M) > CLR(E) > CCL(E) > CLL(M) > CLL(E). Overall, *Curcuma caesia roxb.* exhibited superior antibacterial and antioxidant activities compared with *Curcuma longa L.*, and methanolic extracts were consistently more potent than ethanolic extracts. The findings support the traditional medicinal use of these species and highlight the rhizomes of *Curcuma caesia roxb.* as promising sources of natural antibacterial and antioxidant compounds for future pharmaceutical and nutraceutical applications.

KEYWORDS: *Curcuma caesia roxb.*, *Curcuma longa L.*, antibacterial activity, antioxidant activity, DPPH assay, medicinal plants, rhizome extracts.

INTRODUCTION

Medicinal plants have been used since ancient times as valuable sources of therapeutic agents for the prevention and treatment of various human diseases. In recent years, growing concerns regarding antibacterial resistance and the adverse effects associated with synthetic drugs have increased interest in plant-derived bioactive compounds with antibacterial and antioxidant properties (Gupta *et al.*,2013). Natural antioxidants play an essential role in protecting biological systems from oxidative damage caused by reactive oxygen species (ROS), which are implicated in the pathogenesis of numerous chronic disorders, including cancer, cardiovascular diseases, diabetes, and neurodegenerative

conditions (Chattopadhyay *et al*., 2004). The genus *Curcuma*, belonging to the family Zingiberaceae, comprises more than 120 species distributed throughout tropical and subtropical regions of Asia (Ravindran *et al*.,2007). Several *Curcuma* species are widely utilized in traditional medicine due to their diverse pharmacological properties, including antibacterial, antioxidant, anti-inflammatory, anticancer, hepatoprotective, and immunomodulatory activities (Karmakar *et al*.,2011). Among them, *Curcuma longa L*. (Yellow turmeric) is one of the most extensively studied medicinal plants and is recognized for its high content of curcuminoids and essential oils. *Curcuma caesia roxb*. (black turmeric), characterized by its distinctive bluish-black rhizome, is an important ethnomedicinal plant traditionally used for the treatment of respiratory disorders, wounds, inflammation, bacterial infections, and various other ailments (Mangla *et al*., 2010).

Phytochemical investigations have revealed that *Curcuma* species contain a wide range of biologically active compounds, including curcuminoids, phenolic acids, flavonoids, terpenoids, and volatile oils (Gupta *et al*.,2013). These metabolites are known to contribute significantly to their antioxidant and antimicrobial activities. Previous studies have demonstrated the therapeutic potential of *Curcuma* extracts; however, comparative evaluations of different plant parts and extraction solvents remain limited, particularly for *Curcuma caesia* in relation to *Curcuma longa*.

The biological activity of plant extracts is influenced by several factors, including plant species, plant part, extraction method, and solvent polarity (Chan *et al*.,2008). Methanol and ethanol are among the most commonly used solvents for extracting phenolic and flavonoid compounds, which are largely responsible for antioxidant and antimicrobial effects.

Comparative studies of leaf and rhizome extracts can provide valuable information regarding the distribution of bioactive compounds within the plant and help identify the most promising source of pharmacologically active constituents.

Therefore, the present study was undertaken to evaluate and compare the antibacterial and antioxidant activities of methanolic and ethanolic extracts of leaves and rhizomes of *Curcuma caesia Roxb*. and *Curcuma longa L*. (Karmakar *et al*.,2011). Antibacterial activity was assessed against selected Gram-positive and Gram-negative bacterial pathogens using the agar well diffusion method, while antioxidant potential was determined using the DPPH free radical scavenging assay. The study aimed to identify the most effective extract and to provide scientific evidence supporting the medicinal value of these important *Curcuma* species.

MATERIALS AND METHODS

Plant Material Collection

The whole plant material of *Curcuma caesia roxb*. and *Curcuma longa L*. was collected in month of October 2024 from nearby nursery Bhilai, Chhattishgarh and authenticated based on morphological characteristics in the Department of Botany, Guru Ghasidas Vishwavidyalaya, Koni (Bilaspur), Chhattisgarh, India and and voucher specimen was deposited in the herbarium of the Institute.

Preparation of plant extract

Fresh rhizomes and leaves (leaves were harvested after 90–150 days) were thoroughly washed, cleaned, sliced, and sun-dried for one week, followed by oven drying at 60 °C for 6 hours. The dried rhizomes and leaves were then cut into small pieces and finely powdered using an electronic mill. A total of 50 g of the powdered sample was macerated with

ethanol and methanol in a 1:10 (w/v) ratio and incubated for 24 hours at room temperature with intermittent shaking on an orbital shaker at 125 rpm. The mixture was subsequently filtered through Whatman No. 1 filter paper, and the filtrate was concentrated using a rotary evaporator.

Microorganisms

The microbial strains are used for the antimicrobial activities includes Gram-positive and gram-negative strains (*Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa* and *Klebsiella Pneumoniae*). the test bacterial cultures were obtained from the Microbiology Department, Shri Shankaracharya Institute of Medical Science, Junwani, Durg, Chhattisgarh. The culture is maintained by sub culturing periodically using nutrient agar medium for bacterial strain, which were preserved at 4°C prior to use.

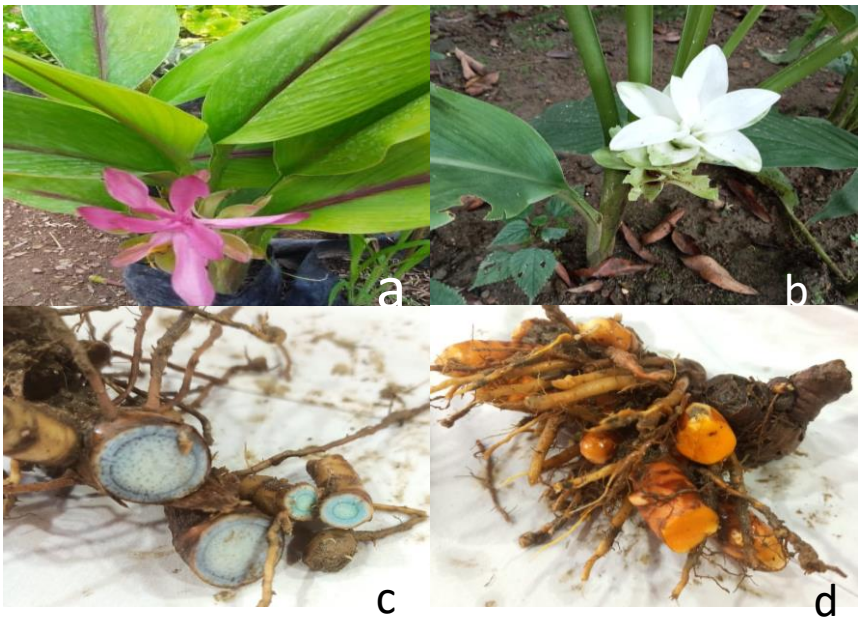

Fig1: (a) *Curcuma caesia roxb*. (Leaves and flowers (c) rhizome), (b) *Curcuma longa L.* (Leaves and flowers (d) rhizome).

Antibacterial Activity

Antibacterial activity of the ethanolic and methanolic extracts of leaves and rhizomes of *Curcuma caesia roxb*. and *Curcuma longa L*. was evaluated using the agar well diffusion method as described by Biruhalem et al. (2011) with slight modifications. Nutrient agar medium (NaCl 5 g/L, peptone 5 g/L, beef extract 3 g/L, agar 15 g/L; pH 6.8) was prepared and sterilized before pouring into Petri plates. Bacterial inoculum was adjusted to 0.5 McFarland standard (approximately 1×10^8 CFU/ml) and uniformly spread onto the agar surface using a sterile cotton swab. Wells of 6 mm diameter were aseptically punched into the agar using a sterile cork borer. Ethanolic and methanolic extracts of leaves and rhizomes were tested at concentrations of 25, 50, and 100 mg/ml, and 100 µl of each extract was introduced into the respective wells. Streptomycin (30 µg/disc) was used as the positive control, while the ethanol serves as the negative control. The plates were allowed to stand at room temperature for 1 h to facilitate diffusion of the extracts and were subsequently incubated at 37°C for 24 h. Antibacterial activity was determined by measuring the diameter of the inhibition zones (mm) around each well. All experiments were performed in triplicate and the results were expressed as mean ± standard deviation (Biruhalem et al., 2011).

DPPH radical scavenging activity

The quenching of free radical activity of different extracts was determined by spectrophotometric method against 2,2-diphenyl-1-picryl hydrazyl (DPPH) following .1 ml of each extract of various concentrations (25–300g/ml) were mixed with 1 ml of DPPH (0.1 mM) solution prepared in ethanol and incubated in dark for 20 min and absorbance values were recorded at 517 nm. 1 ml of ethanol and 1 ml of ethanolic solution of DPPH (0.2 mM) was taken as control.

Similarly, 1 ml of ethanolic solution of ascorbic acid (200 g/ml) was mixed with 1 ml of DPPH ethanolic solution and absorbance values were recorded. The radical scavenging activity was calculated using the following formula:

DPPH radical scavenging activity (%) = Ab − Aa ÷Ab × 100 where Ab is the absorption of the blank and Aa is the absorption of the extract sample.

RESULT AND DISCUSSION

The antibacterial activity of methanolic and ethanolic extracts obtained from the rhizomes and leaves of *Curcuma caesia roxb.* and *Curcuma longa L*. was evaluated against four pathogenic bacterial strains, namely *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Klebsiella pneumoniae*, using the agar well diffusion method. The results are expressed as mean zone of inhibition (mm) ± standard deviation and are presented in Table 1.

Table 1: Antibacterial Activity of Methanol and Ethanol Extracts of *Curcuma caesia roxb.* and *Curcuma longa L.* Against Selected Bacterial Strains (Zone of Inhibition, mm; mm; Mean ± SEM; n=3).

Bacterial species	*Escherichia coli*	*Staphylococcus aureus*	*Pseudomonas aeruginosa*	*Klebsiella pneumoniae*
Rhizome				
CCR (M)	18.53 ± 0.20	21.27 ± 0.32	15.87 ± 0.18	19.43 ± 0.20
CCR (E)	16.87 ± 0.23	19.73 ± 0.26	14.23 ± 0.15	17.86 ± 0.18
CLR(M)	15.10 ± 0.17	17.43 ± 0.20	12.63 ± 0.15	16.03 ± 0.15
CLR(E)	13.67 ± 0.18	15.80 ± 0.17	11.43 ± 0.12	14.60 ± 0.12
Leaf				
CCL (M)	14.13 ± 0.20	17.90 ± 0.17	13.20 ± 0.17	15.70 ± 0.17
CCL (E)	12.73 ± 0.18	15.93 ± 0.20	11.80 ± 0.12	14.27 ± 0.15
CLL (M)	11.80 ± 0.17	15.00 ± 0.17	10.50 ± 0.17	13.40 ± 0.17
CLL (E)	10.27 ± 0.15	13.60 ± 0.12	9.20 ± 0.12	11.93 ± 0.15
Ethanol	ND	ND	ND	ND
Streptomycin	28.10 ± 0.17	30.17 ± 0.20	24.93 ± 0.15	27.03 ± 0.15

(CC: Curcuma Caesia; CL: Curcuma Longa; R:rhizome; L: Leaf; M:methanol; E: Ethanol)

Among all tested extracts, the methanolic rhizome extract of *Curcuma caesia roxb.* exhibited the highest antibacterial activity against all bacterial strains. The maximum inhibition zone was observed against *Staphylococcus aureus* (21.27 ± 0.32 mm), followed by *Klebsiella pneumoniae* (19.43 ± 0.20 mm), *Escherichia coli* (18.53 ± 0.20 mm), and *Pseudomonas aeruginosa* (15.87 ± 0.18 mm). The ethanolic rhizome extract of *Curcuma caesia roxb.* also demonstrated considerable antibacterial activity; however, its efficacy was lower than that of the corresponding methanolic extract.

Leaf extracts of *Curcuma caesia roxb.* showed moderate antibacterial activity against all tested microorganisms. The methanolic leaf extract produced inhibition zones ranging from 13.20 ± 0.17 mm to 17.90 ± 0.17 mm, whereas the ethanolic leaf extract showed comparatively lower activity, with inhibition zones ranging from 11.80 ± 0.12 mm to 15.93 ± 0.20 mm.

In *Curcuma longa L*, both rhizome and leaf extracts exhibited antibacterial activity, although the inhibitory effects were generally lower than those observed for Curcuma *caesia roxb.* The methanolic rhizome extract of *Curcuma longa L.*

Produced inhibition zones ranging from 12.63 ± 0.15 mm to 17.43 ± 0.20 mm, while the ethanolic rhizome extract showed inhibition zones between 11.43 ± 0.12 mm and 15.80 ± 0.17 mm. The leaf extracts of *Curcuma longa L.* displayed the least antibacterial activity among all tested plant samples, with inhibition zones ranging from 9.20 ± 0.12 mm to 15.00 ± 0.17 mm.

A comparison of extraction solvents revealed that methanolic extracts consistently exhibited greater antibacterial activity than ethanolic extracts in both species. Furthermore, rhizome extracts were more effective than leaf extracts, suggesting a higher accumulation of bioactive antimicrobial constituents in the rhizomes. (Biruhalem et al., 2011). Overall, *Curcuma caesia roxb.* demonstrated superior antibacterial potential compared to *Curcuma longa L.* against all tested bacterial pathogens.

These findings indicate that the rhizomes of *Curcuma caesia roxb.*, particularly the methanolic extract, possess promising antibacterial properties and may serve as a potential source of natural antimicrobial agents for further pharmacological investigation.

Antioxidant activity

The antioxidant potential of methanolic and ethanolic extracts obtained from the leaves and rhizomes of *Curcuma caesia roxb*. and *Curcuma longa L*. was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical scavenging assay. All extracts exhibited concentration-dependent antioxidant activity, with the percentage inhibition increasing progressively as the concentration increased from 25 to 300 µg/ml. This gradual increase in DPPH radical scavenging activity indicates an enhanced ability of the extracts to neutralize free radicals at higher concentrations.

DPPH Radical Scavenging Activity of Leaf Extracts

The DPPH radical scavenging activity of leaf extracts revealed significant differences among the tested samples. The methanolic leaf extract of *Curcuma caesia roxb.* [CC(M)] exhibited the highest antioxidant activity among the plant extracts, achieving 74.60 ± 0.73% inhibition at 300 µg/ml and an IC_{50} value of 145.0 ± 3.5 µg/ml. The ethanolic leaf extract of *Curcuma caesia roxb.* [CC(E)] showed slightly lower activity, with an IC_{50} value of 154.1 ± 4.2 µg/ml.

Table 2: Antioxidant Activity of Methanol and Ethanol leaves Extracts of *Curcuma caesia roxb.* and *Curcuma longa L.* (% Inhibition, Mean ± SEM (n=3).

Control Absorbance = 1.378					
Conc. (µg/ml)	**CCL(E) (%)**	**CLL(E) (%)**	**CCL(M) (%)**	**CLL(M) (%)**	**Ascorbic Acid (%)**
25	11.47 ± 0.73	8.56 ± 0.73	13.64 ± 0.73	12.19 ± 0.73	28.88 ± 1.09
50	23.08 ± 0.73	18.00 ± 0.73	26.71 ± 0.73	23.08 ± 0.73	43.40 ± 0.87
100	33.96 ± 0.73	26.71 ± 0.73	39.77 ± 0.73	33.96 ± 0.73	59.36 ± 0.73
150	47.02 ± 0.73	36.87 ± 0.73	51.38 ± 0.73	47.02 ± 0.73	74.60 ± 0.73
200	59.36 ± 0.73	48.48 ± 0.73	63.00 ± 0.73	55.73 ± 0.73	85.49 ± 0.73
300	71.70 ± 0.73	61.54 ± 0.73	74.60 ± 0.73	68.80 ± 0.73	91.29 ± 0.58

(CCL: *Curcuma caesia* Leaf, CLL: *Curcuma longa* Leaf, E: Ethanol,M: Methanol.)

Among the *Curcuma longa L.* leaf extracts, the methanolic extract [CL(M)] demonstrated moderate antioxidant activity with an IC_{50} value of 162.8 ± 3.8 µg/ml, whereas the ethanolic extract [CL(E)] exhibited the lowest activity, producing 68.80 ± 0.73% inhibition at 300 µg/ml and an IC_{50} value of 206.8 ± 5.1 µg/ml.

Ascorbic acid, used as the reference standard, showed the strongest antioxidant activity with 91.29 ± 0.58% inhibition at 300 µg/ml and the lowest IC_{50} value of 78.2 ± 2.1 µg/ml. Statistical analysis using one-way ANOVA revealed significant differences ($p < 0.05$) among the extracts. The antioxidant activity of leaf extracts followed the order:

Ascorbic Acid > CC(M) > CC(E) > CL(M) > CL(E)

Table 3: IC_{50} Values and Statistical Analysis of DPPH Radical Scavenging Activity of *Curcuma caesia roxb.* and *Curcuma longa L.* Leaf Extracts.

Sample	IC_{50} (µg/ml)
Ascorbic Acid	78.2 ± 2.1^{e}
CCL(M) (*Curcuma caesia* Leaf Methanol)	145.0 ± 3.5^{d}
CCL(E) (*Curcuma caesia* Leaf Ethanol)	154.1 ± 4.2^{c}
CLL(M) (*Curcuma longa* Leaf Methanol)	162.8 ± 3.8^{b}
CLL(E) (*Curcuma longa* Leaf Ethanol)	206.8 ± 5.1^{a}

Data represents mean± SEM, n=3. Means sharing the same letter do not different significantly at P≤0.05

The results suggest that *Curcuma caesia roxb.* leaves possess greater antioxidant potential than *Curcuma longa L.* leaves, and methanolic extraction is more efficient in recovering antioxidant constituents than ethanol extraction.

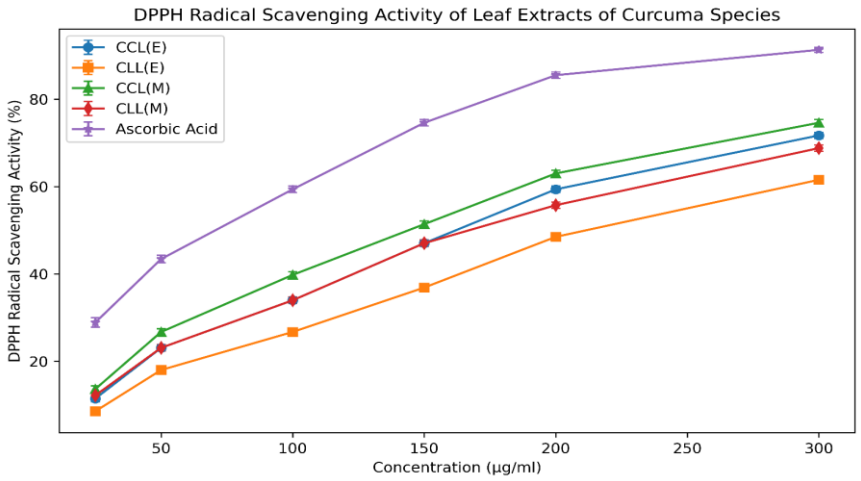

Fig 2: DPPH Radical Scavenging Activity of leaves Extracts (% Inhibition).

DPPH Radical Scavenging Activity of Rhizome Extracts (% Inhibition)

Among the tested samples, the methanolic rhizome extract of *Curcuma caesia* [CCR(M)] exhibited the highest antioxidant activity among the plant extracts. At a concentration of 300 µg/ml, CCR(M) showed 86.27 ± 0.58% inhibition, followed by the ethanolic rhizome extract of *Curcuma caesia* [CCR(E)] with 81.37 ± 0.58% inhibition. The methanolic rhizome extract of *Curcuma. longa* [CLR(M)] demonstrated 80.39 ± 0.58% inhibition, whereas the ethanolic rhizome extract [CLR(E)] exhibited comparatively lower activity with 74.50 ± 0.58% inhibition at the same concentration. The antioxidant activity of the rhizome extracts followed the order:Ascorbic Acid > CCR(M) > CCR(E) > CLR(M) > CLR(E).

Table 4: Antioxidant Activity of Methanol and Ethanol rhizome Extracts of *Curcuma caesia roxb.* and *Curcuma longa L* (% Inhibition, Mean ± SEM (n=3).

(Control Absorbance = 1.02)					
Conc.(µg/ml)	**CCR(E) (%)**	**CLR(E) (%)**	**CCR(M) (%)**	**CLR(M) (%)**	**Ascorbic Acid (%)**
25	18.62 ± 0.73	15.68 ± 0.73	22.54 ± 0.73	19.60 ± 0.73	28.43 ± 1.09
50	30.39 ± 0.73	26.47 ± 0.73	35.29 ± 0.73	31.37 ± 0.73	42.16 ± 0.87
100	43.13 ± 0.73	38.23 ± 0.73	49.01 ± 0.73	44.11 ± 0.73	58.82 ± 0.73
150	56.86 ± 0.73	50.98 ± 0.73	62.74 ± 0.73	57.84 ± 0.73	71.57 ± 0.73
200	68.62 ± 0.73	62.74 ± 0.73	74.50 ± 0.73	69.60 ± 0.73	84.31 ± 0.73
300	81.37 ± 0.58	74.50 ± 0.58	86.27 ± 0.58	80.39 ± 0.58	91.18 ± 0.58

(CCR: Curcuma caesia Rhizome, CLR: Curcuma longa Rhizome, E: Ethanol: Methanol.)

Among the rhizome extracts, CCR(M) exhibited the lowest IC_{50} value (104.5 ± 3.5 µg/ml), indicating the strongest antioxidant activity, followed by CCR(E) (128.4 ± 4.2 µg/ml), CLR(M) (141.7 ± 3.8 µg/ml), and CLR(E) (156.2 ± 4.5 µg/ml).Ascorbic acid, used as the reference standard, demonstrated the highest free radical scavenging activity with 91.18 ± 0.58% inhibition at 300 µg/ml and the lowest IC_{50} value (78.2 ± 2.1 µg/ml).

Table 5: IC_{50} Values and Statistical Analysis of DPPH Radical Scavenging Activity of *Curcuma caesia roxb.* and *Curcuma longa L.* rhizome Extracts.

Sample	**IC_{50} (µg/ml)**
Ascorbic acid	78.2 ± 2.1^{e}
CCR(M)	104.5 ± 3.5^{d}
CCR(E)	128.4 ± 4.2^{c}
CLR(M)	141.7 ± 3.8^{b}
CLR(E)	156.2 ± 4.5^{a}

Data represents mean± SEM, n=3. Means sharing the same letter do not different significantly at P≤0.05

These results demonstrate that *Curcuma caesia roxb.* possesses greater antioxidant potential than *Curcuma longa L.*, while methanolic extracts exhibit stronger DPPH radical scavenging activity than the corresponding ethanolic extracts. The superior antioxidant activity of *Curcuma caesia roxb.* rhizome extracts may be attributed to a higher concentration of phenolic compounds, flavonoids, curcuminoids, and other bioactive constituents capable of donating hydrogen atoms to neutralize free radicals. Overall, the findings suggest that the methanolic rhizome extract of *Curcuma caesia roxb.* is a promising natural source of antioxidant compounds with potential pharmaceutical and nutraceutical applications.

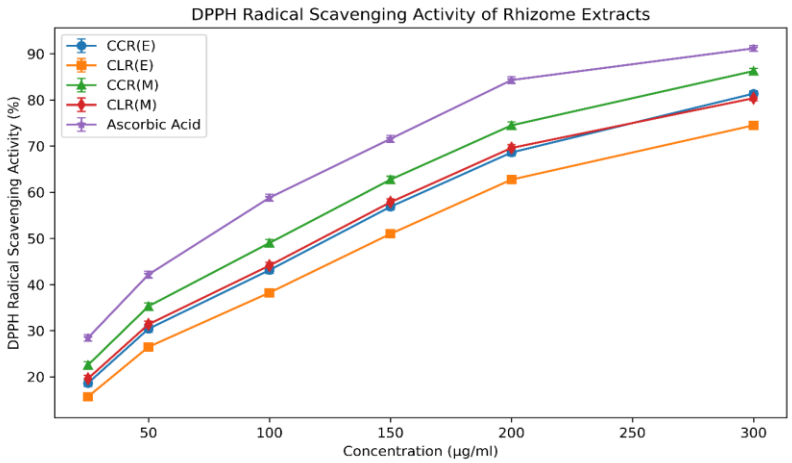

Fig 3: DPPH Radical Scavenging Activity of Rhizome Extracts (% Inhibition).

Comparative Analysis of DPPH Antioxidant Activity of Leaf and Rhizome Extracts.

The antioxidant activity of methanolic and ethanolic extracts of leaves and rhizomes of *Curcuma caesia roxb.* and *Curcuma longa L.* was assessed using the DPPH radical scavenging assay. A comparative evaluation of the IC_{50} values revealed significant differences between plant parts, species, and extraction solvents. The results showed that rhizome extracts possessed stronger antioxidant activity than the corresponding leaf extracts, as evidenced by their lower IC_{50} values.

Among all plant extracts, the methanolic rhizome extract of *Curcuma caesia* [CCR(M)] exhibited the strongest antioxidant activity with an IC_{50} value of 104.5 ± 3.5 µg/ml, followed by the ethanolic rhizome extract [CCR(E)] (128.4 ± 4.2 µg/ml). In contrast, the leaf extracts of *Curcuma caesia* showed comparatively higher IC_{50} values, with CCL(M) and CCL(E) recording 145.0 ± 3.5 µg/ml and 154.1 ± 4.2 µg/ml, respectively. Similarly, rhizome extracts of *C. longa* exhibited better antioxidant activity than the corresponding leaf extracts, with CLR(M) (141.7 ± 3.8 µg/ml) and CLR(E) (156.2 ± 4.5 µg/ml) showing lower IC_{50} values than CLL(M) (162.8 ± 3.8 µg/ml) and CLL(E) (206.8 ± 5.1 µg/ml).

Overall, the antioxidant activity followed the order:
Ascorbic Acid > CCR(M) > CCR(E) > CLR(M) > CCL(M) > CLR(E) > CCL(E) > CLL(M) > CLL(E)

These findings indicate that Rhizomes exhibited greater antioxidant potential than leaves. *Curcuma caesia roxb.* showed stronger antioxidant activity than *Curcuma longa L*. The methanolic rhizome extract of *Curcuma caesia roxb.* was the most potent natural antioxidant source among the tested samples.

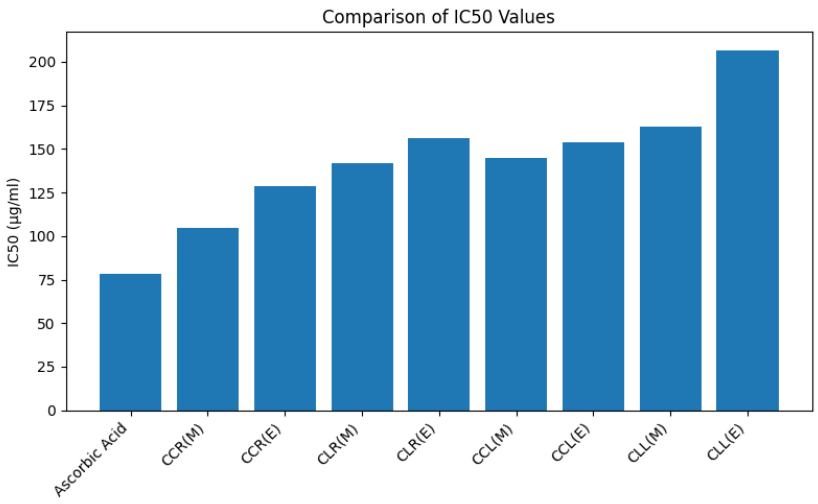

Fig 4: Comparative Analysis of DPPH Antioxidant Activity of Leaf and Rhizome Extracts of both *Curcuma caesia roxb.*and *Curcuma longa L.*

These findings indicate that Rhizomes exhibited greater antioxidant potential than leaves. *Curcuma caesia roxb.* showed stronger antioxidant activity than *Curcuma longa L*. The methanolic rhizome extract of *Curcuma caesia roxb.* was the most potent natural antioxidant source among the tested samples.

REFERENCES

1. Chattopadhyay, I., Biswas, K., Bandyopadhyay, U., & Banerjee, R.K., Turmeric and curcumin: Biological actions and medicinal applications. *Current Science*, 2004.
2. Gupta, S.C., Patchva, S., Koh, W., & Aggarwal, B.B., Discovery of curcumin, a component of golden spice, and its miraculous biological activities. *Clinical and Experimental Pharmacology and Physiology*, 2013.
3. Ravindran, P.N., Babu, K.N., & Sivaraman, K., *Turmeric: The Genus Curcuma*. CRC Press, Boca Raton, USA, 2007.
4. Karmakar, I., Dolai, N., Saha, P., Sarkar, N., Bala, A., & Haldar, P.K., Scavenging activity of Curcuma caesia rhizome against reactive oxygen and nitrogen species. *Oriental Pharmacy and Experimental Medicine*, 2011.
5. Mangla, M., Pathak, A.K., & Dikshit, P., Antioxidant activity of *Curcuma caesia Roxb*. *Indian Journal of Pharmaceutical Sciences*, 2010.
6. Chan, E.W.C., Lim, Y.Y., Wong, L.F., et al., Antioxidant and tyrosinase inhibition properties of leaves and rhizomes of ginger species, 2008.
7. Biruhalem T, Mirutse G, Abebe A and Jemal S, "Antibacterial activities of selected medicinal plants in traditional treatment of human wounds in Ethiopia", Asian Pacific Journal of Tropical Biomedicine, 2011.
8. M.S. Blois, Antioxidant determination by the use of stable free radicals, Nature, 1958.
9. Mishra, S.; Verma, S.S.; Rai, V.; Awasthee, N.; Arya, J.S.; Maiti, K.K.; Gupta, S.S., *Curcuma* raktakanda induces apoptosis and suppresses migration in cancer cells: Role of reactive oxygen species, 2019.
10. Liu, B.; Gao, Y.Q.; Wang, X.M.; Wang, Y.C.; Fu, L.Q., Germacrone inhibits the proliferation of glioma cells by promoting apoptosis and inducing cell cycle arrest, 2024.