

## “Research on Complete Pharmacognostic Study on Curcuma Longa & It’s Uses in Nanotechnology”

Sakshi Gajanan Wagh<sup>1</sup>, Ansari Kubra Tabassum<sup>2</sup>, Dr. N. V. N. Reddy<sup>3</sup>,  
Dr. Sameer S. Sheikh<sup>4</sup>

<sup>1</sup>Students (Durgamata institute of Pharmacy Dharmapuri)

<sup>2</sup>(Assistant Professor) Guide

<sup>3</sup>(HOD of Pharmacognosy)<sup>3</sup>

<sup>4</sup>(Principal Durgamata Institute of Pharmacy Dharmapuri)  
Durgamata Institute of Pharmacy Dharmapuri.

Date of Submission: 25-05-2026

Date of Acceptance: 02-06-2026

### ABSTRACT

Pharmacognosy and Curcuma longa have gained significant attention due to their wide range of medicinal and pharmaceutical applications. Curcuma longa (Turmeric), belonging to the family Zingiberaceae, is a well-known medicinal plant extensively used in traditional systems of medicine such as Ayurveda, Siddha, and Unani. The rhizome of turmeric contains important bioactive constituents including curcumin, desmethoxycurcumin, bisdemethoxycurcumin, volatile oils, proteins, carbohydrates, and minerals, which are responsible for its therapeutic properties. The present study focuses on the complete pharmacognostic evaluation of Curcuma longa and its emerging applications in nanotechnology.

The pharmacognostic study includes macroscopic, microscopic, physicochemical, and phytochemical evaluation of turmeric rhizomes. Macroscopic analysis revealed characteristic yellowish-orange color, aromatic odor, rough surface, and bitter taste. Microscopic examination showed the presence of cork cells, starch grains, oleoresin cells, vascular bundles, and parenchymatous tissues. Physicochemical parameters such as ash values, extractive values, moisture content, and fluorescence analysis were carried out to establish quality standards for identification and authentication of the crude drug. Preliminary phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, glycosides, phenolic compounds, and curcuminoids.

In recent years, nanotechnology has emerged as an innovative approach to enhance the therapeutic efficacy of herbal drugs. Curcumin, the principal active constituent of turmeric, possesses antioxidant, anti-inflammatory, antimicrobial, anticancer, wound

healing, and hepatoprotective activities; however, its clinical application is limited due to poor solubility, low bioavailability, and rapid metabolism. Nanotechnology-based drug delivery systems such as nanoparticles, Nano emulsions, liposomes, Nano capsules, and solid lipid nanoparticles have been developed to overcome these limitations. Nano formulations of curcumin improve its stability, absorption, targeted delivery, and therapeutic effectiveness.

The study concludes that Curcuma longa is an important medicinal plant with significant pharmacognostic characteristics and immense potential in modern nanotechnology-based healthcare applications. The integration of traditional herbal medicine with advanced nanotechnology can contribute to the development of safer, more effective, and targeted therapeutic systems for the treatment of various diseases

### I. INTRODUCTION

#### 1. General Introduction of Curcuma longa:

Curcuma longa, commonly known as turmeric, is one of the most important medicinal plants used in traditional and modern systems of medicine. It belongs to the family Zingiberaceae and is widely cultivated in tropical countries, especially in India. Turmeric has been used for centuries as a spice, coloring agent, cosmetic ingredient, and herbal medicine due to its remarkable therapeutic properties. The rhizome of turmeric contains several bioactive compounds, among which curcumin is the principal active constituent responsible for most of its pharmacological activities.

#### 1.1 Importance of Pharmacognostic Study

Pharmacognosy deals with the study of medicinal drugs obtained from natural sources such as plants,

animals, and minerals. Pharmacognostic evaluation is essential for:

- Identification and authentication of crude drugs
- Detection of adulteration and substitution
- Standardization of herbal medicines
- Determination of purity and quality
- Establishment of pharmacopoeial standards

Pharmacognostic studies include macroscopic, microscopic, physicochemical, and phytochemical evaluations which help in ensuring the safety and efficacy of herbal drugs.

(Shivkanya fuloria et al., 2022)

## 1.2 Botanical Description of Turmeric

### Taxonomical Classification

- Kingdom: Plantae
- Division: Angiosperms
- Class: Monocotyledons
- Order: Zingiberales
- Family: Zingiberaceae
- Genus: Curcuma

### Morphological Features

- Turmeric is a perennial herbaceous plant.
- It possesses underground branched rhizomes with yellow-orange coloration.
- Leaves are broad, oblong, and green in color.
- The plant grows approximately 1 meter in height.
- Rhizomes possess a characteristic aromatic odor and bitter taste.

## 1.3 Microscopic Characteristics

Microscopic examination of turmeric rhizome shows:

- Cork cells
- Thin-walled parenchymatous cells
- Oleoresin cells
- Starch grains
- Fibrovascular bundles

These microscopic features are important for the authentication and identification of turmeric powder and crude drug materials

## 1.4 Chemical Constituents of Turmeric

Turmeric contains various phytoconstituents such as:

- Curcumin
- Desmethoxycurcumin
- Bisdemethoxycurcumin
- Volatile oils
- Proteins
- Carbohydrates
- Flavonoids
  
- Tannins
- Resins

Curcumin is considered the major biologically active constituent and exhibits numerous therapeutic activities including antioxidant, anti-inflammatory, antimicrobial, anticancer, hepatoprotective, and wound healing properties.

(Murali M. Yallapu et al., 2015)

## 1.5 Medicinal Importance of Turmeric

Turmeric has been extensively used in Ayurveda, Siddha, and Unani medicine for the treatment of:

- Skin diseases
- Wounds and infections
- Diabetes
- Liver disorders
- Respiratory disorders
- Digestive problems
- Inflammatory conditions

Modern scientific studies have also demonstrated the role of curcumin in cancer prevention, cardiovascular protection, neuroprotection, and immune modulation

(Murali M. Yallapu et al., 2015)

## 1.6 Need for Nanotechnology in Curcumin Delivery

Although curcumin possesses excellent therapeutic properties, its clinical application is limited because of:

- Poor water solubility
- Low bioavailability
- Rapid metabolism
- Poor absorption
- Fast systemic elimination

To overcome these limitations, Nanotechnology has emerged as a promising approach for improving the therapeutic efficacy of curcumin. Nanotechnology-based formulations enhance:

- Solubility

- Stability
  - Drug absorption
  - Controlled drug release
  - Target-specific delivery
  - Bioavailability of curcumin.
- (Gabriela et al., 2024)

### 1.7 Nano formulations of Curcumin

Various nanocarrier systems developed for curcumin include:

- Polymeric nanoparticles
- Liposomes
- Nano emulsions
- Micelles
- Nano capsules
- Solid lipid nanoparticles
- Metallic nanoparticles

These Nano formulations improve pharmacokinetic properties and therapeutic effectiveness of curcumin in several diseases.

(Shery Jacob et al., 2024)

### 1.8. Applications of Curcumin Nanotechnology

Curcumin Nano formulations are widely studied in:

- Cancer therapy
- Antimicrobial treatment
- Anti-inflammatory therapy
- Brain-targeted drug delivery
- Wound healing
- Cardiovascular diseases
- Neurodegenerative disorder

(Komal Rajak, Hemant Kumar et al., 2023)

## II. AIM & OBJECTIVES

### 2.1 AIM-

To carry out a complete pharmacognostic study of *Curcuma longa* and to evaluate its potential applications in nanotechnology for enhancement of therapeutic efficacy and bioavailability.

### 2.2 OBJECTIVE -

- 1.To collect and identify *Curcuma longa* rhizomes.
- 2.To study the physical characteristics of turmeric such as color, smell, taste and shape.
- 3.To examine the microscopic structure of turmeric.
- 4.To test the purity and quality of turmeric

powder.

5.To identify important chemical compounds present in turmeric.

6.To study the medicinal properties of curcumin present in turmeric.

7.To prepare nano-sized curcumin formulation using nanotechnology.

8.To improve the solubility and absorption of curcumin by nanoformulation.

9.To compare the activity of normal curcumin and nano-curcumin.

10.To understand the use of nanotechnology in improving the therapeutic effect of turmeric

## 2025-26 PLAN OF WORK

### 1. PLAN OF WORK

#### 1. Collection of Plant Material

Collection of rhizomes of *Curcuma longa* from local market or herbal source.

#### 2. Authentication of Plant Material

Identification and authentication of the collected sample by expert or pharmacognosy department.

#### 3. Preparation of Sample

Cleaning, drying and powdering of turmeric rhizomes for further studies.

#### 4. Macroscopic Evaluation

Study of color, odor, taste, size, shape and texture of turmeric rhizomes.

#### 5. Microscopic Evaluation

Preparation of transverse section and observation of microscopic characters.

#### 6. Powder Microscopy

Examination of powdered drug for identification of diagnostic features.

#### 7. Physicochemical Analysis

Determination of:

- Ash values
- Extractive values
- Loss on drying
- Moisture content

#### 8. Fluorescence Analysis

Observation of powder behavior under visible and UV light using different reagents.

#### 9. Phytochemical Screening

Identification of active constituents such as curcuminoids, flavonoids and phenolic compounds.

#### 10. Extraction of Curcumin

Preparation of extract from turmeric rhizomes using suitable solvent extraction method.

#### 11. Preparation of Nano formulation

Formulation of nano-curcumin using

nanoprecipitation or suitable nanotechnology method.

12. Evaluation of Nano formulation Study of:

- Particle size
- Drug entrapment efficiency
- Stability

- Drug release pattern

13. Antioxidant Activity Study

Comparison of antioxidant activity of crude extract and Nano-curcumin.

14. Result and Discussion

Interpretation and discussion of obtained results.

III. LITERATURE SURVEY

A literature survey has been done as follows:

Table no. 1: Literature Survey of Curcuma longa and Nanotechnology Applications.

Sr. No	Author	Activity	Plant Part	Extract / Dose / Route	Standard Drug & Dose	Model	Chemical Constituent
1	Yallapu MM et al. (2015)	Anticancer Activity	Rhizome	Curcumin nanoparticles (50 mg/kg) Oral	Free Curcumin (50 mg/kg)	Tumor induced model	Curcumin
2	Jacob S et al. (2024)	Nano drug delivery	Rhizome	Nanoemulsion formulation	Conventional Curcumin	In-vitro study	Curcuminoids
3	Sharma RA et al. (2005)	Antioxidant Activity	Rhizome	Ethanollic extract (200 mg/kg) Oral	Vitamin C	Oxidative stress model	Phenolic compounds
4	Gupta SC et al. (2013)	Anti-inflammatory Activity	Rhizome	Aqueous extract (100 & 200 mg/kg) Oral	Diclofenac (10 mg/kg)	Carrageenan induced paw edema	Curcumin and flavonoids
5	Anand P et al. (2007)	Bioavailability Study	Rhizome	Curcumin liposomes	Plain curcumin	Pharmacokinetic study	Curcumin
6	Aggarwal BB et al. (2007)	Antimicrobial Activity	Rhizome	Methanolic extract (250 mg/kg)	Ciprofloxacin	Antibacterial assay	Volatile oils and curcumin
7	Basniwal RK et al. (2011)	Nanoparticle formulation	Rhizome	Solid lipid nanoparticles	Conventional suspension	Drug release study	Curcuminoids
8	Menon VP et al. (2007)	Hepatoprotective Activity	Rhizome	Hydroalcoholic extract (300 mg/kg)	Silymarin	CCl4 induced hepatotoxicity	Curcumin

Table no. 2: An activity literature survey

A detailed activity-wise literature survey of Curcuma longa and its nanotechnology applications is presented below.

Sr. No.	Author	Activity	Plant Part	Extract / Formulation	Standard Drug	Experimental Model	Major Findings
---------	--------	----------	------------	-----------------------	---------------	--------------------	----------------

1	Sharma RA et al. (2005)	Antioxidant Activity	Rhizome	Ethanollic Extract	Vitamin C	Oxidative stress model	Curcumin showed strong free radical scavenging activity
2	Gupta SC et al. (2013)	Anti-inflammatory Activity	Rhizome	Aqueous Extract	Diclofenac	Carrageenan induced paw edema	Significant reduction in inflammation observed
3	Yallapu MM et al. (2015)	Anticancer Activity	Rhizome	Curcumin Nanoparticles	Free Curcumin	Tumor induced model	Nano-curcumin enhanced anticancer efficacy
4	Aggarwal BB et al. (2007)	Antimicrobial Activity	Rhizome	Methanolic Extract	Ciprofloxacin	Antibacterial assay	Effective against gram-positive and gram-negative bacteria
5	Menon VP et al. (2007)	Hepatoprotective Activity	Rhizome	Hydroalcoholic Extract	Silymarin	CCl4 induced hepatotoxicity	Liver protection and reduction in oxidative damage observed
6	Pandey DK et al. (2020)	Antidiabetic Activity	Rhizome	Ethanollic Extract	Metformin	Streptozotocin induced diabetes	Significant reduction in blood glucose level

#### IV. MATERIALS AND METHODS

##### 4.4 Collection, identification and authentication of plant material

Fresh rhizomes of *Curcuma longa* were collected from local market of Jalna district during the month of February. The collected rhizomes were washed thoroughly with water to remove soil and foreign particles.

The plant material was authenticated by a qualified botanist Dr. S.B Jige the Department of Botany at Sant Ramdas Arts and Science College, Ghansawangi. A voucher specimen was preserved for future reference.



- Powdered material was stored in airtight containers protected from moisture and light. use.

### 5.3 Chemical and Reagent

The following analytical grade chemicals and reagents were used during the study:

- |                   |                     |                         |
|-------------------|---------------------|-------------------------|
| • Ethanol         | • Methanol          | • Ferric chloride       |
| • Distilled water | • Hydrochloric acid | • Mayer's reagent       |
| • Sulphuric acid  | • Nitric acid       | • Dragendorff's reagent |
|                   |                     | • Wagner's reagent      |
|                   |                     | • Sodium hydroxide      |
|                   |                     | • Chloroform            |
|                   |                     | • Acetic anhydride      |
|                   |                     | • Lead acetate          |
|                   |                     | • Benedict's reagent    |
|                   |                     | • Fehling's solution    |
|                   |                     | • DPPH reagent          |

## HERBARIUM SHEET



Curcumin Powder



Rhizome

Category	Classification
Kingdom	Plantae
Division	Angiosperms
Class	Monocotyledonae
Order	Zingiberales
Family	Zingiberaceae
Genus	Curcuma
Species	Curcuma longa Linn.

Image No- 04 Herbarium sheet

### 5.4 Instrument and Apparatus

The following instruments were used:

Sr No	Instrument / Apparatus
01	Compound microscope
02	Soxhlet apparatus
03	Hot air oven
04	UV-visible spectrophotometer
05	Electronic balance
06	Water bath

07	Mechanical grinder
08	Centrifuge
09	pH meter
10	Magnetic stirrer

Table -03 Instrument uses

### 5.5 Pharmacognostic Evaluation

Pharmacognostic evaluation of turmeric rhizomes was carried out using standard procedures.

#### 5.5.1 Macroscopic Evaluation

Macroscopic evaluation was performed to determine the external morphological features of turmeric

rhizomes.

**Parameters Studied:**

- Color
- Size
- Shape
- Surface characteristics
- Texture
- Odor
- Taste

**Observation:**

- Rhizomes were yellowish-orange internally.
- Characteristic aromatic odor was observed.
- Taste was slightly bitter and pungent.
- Surface appeared rough with annulations.

**5.5.2 Microscopic Evaluation**

**Preparation of Transverse Section (T.S.)**

- Thin transverse sections of rhizome were prepared using a sharp blade.
- Sections were stained using phloroglucinol and hydrochloric acid.
- Prepared sections were mounted in glycerin.
- Sections were observed under compound microscope.

**5.6.1 Determination of Ash values of crude drug**



**Image no 5 & 6: Ash formed during process**

**A) Total Ash value**

1. About 2 g of accurately weighed powdered turmeric rhizome was taken in a previously ignited and weighed silica crucible.
2. The sample was spread evenly.
3. The crucible was gradually heated and incinerated at temperature not exceeding 450°C until carbon-free white ash was obtained.
4. Crucible was cooled in desiccator and weighed.

**Microscopic Characters Observed:**

- Cork cells
- Cortex
- Parenchymatous cells
- Starch grains
- Oleoresin cells
- Vascular bundles
- Fibers

**5.5.3 Powder Microscopy**

Powdered rhizome was treated with different reagents and observed microscopically for:

- Starch grains
- Fibers
- Cork cells
- Xylem vessel

**5.6 Physical Evaluation**

The dried rhizome powder of the plant was used for the determination of physicochemical parameters such as Total Ash value, Acid Insoluble Ash value, Water Soluble Ash value, and Moisture Content (LOD).

5. Total ash value was calculated with reference to air-dried drug, drug.

$$\text{Total ash value (\%)} = \frac{\text{Weight of Ash}}{\text{Weight of air - dried drug}} \times 100$$

(Amruta Balekundri et al- 2020)

**B) Determination of Acid-Insoluble Ash value**

1. Total ash obtained was boiled with 25 mL

dilute hydrochloric acid for 5 minutes.

2. Insoluble matter was filtered through ashless filter paper.

3. Residue was washed with hot water until neutral.

4. Filter paper with residue was ignited in crucible.

5. Residue was cooled and weighed.

$$\text{Acid insoluble ash (\%)} = \frac{\text{Weight of acid insoluble Ash}}{\text{Weight of drug}} \times 100$$

WHO., 2011)

### C) Determination of Water-soluble Ash

1. Total ash was boiled with 25 mL distilled water.

2. Insoluble matter was filtered.

3. Residue was ignited and weighed.

4. Difference between total ash and residue gave water soluble ash.

$$\text{Water soluble ash} = \text{Total Ash} - \text{Insoluble Ash}$$

(WHO., 2011)

### 5.6.2 Determination of Loss on Drying (LOD)

1. About 2 g powdered turmeric rhizome was accurately weighed.

2. Sample was placed in evaporating dish.

3. Dish was dried in hot air oven at 105°C.

4. Drying continued until constant weight obtained.

5. Dish was cooled in desiccator and weighed.

$$\text{Loss on drying (\%)} = \frac{\text{Initial Weight} - \text{Final weight}}{\text{Initial Weight}} \times 100$$

QCM.WHO, 2011)

### 5.6.3 Determination extractive value

Extractive values indicate quantity of active constituents soluble in specific solvents. Extractive value analysis helps estimate chemical constituents present in crude drug.

### a) Determination of Water-soluble Extractive Values

1. About 5 g powdered drug was macerated with 100 mL chloroform water.

2. Mixture was shaken frequently for 6 hours.

3. Allowed to stand for 18 hours.

4. Solution was filtered.

5. 25 mL filtrate was evaporated to dryness.

6. Residue was dried and weighed..

(Amruta Balekundri, 2020)

### b) (Determination of Alcohol-Soluble Extractive Values

1. About 5 g powdered drug was macerated with 100 mL ethanol in closed flask for 24 hours.

2. Mixture was shaken frequently during first 6 hours.

3. Solution was filtered rapidly.

4. 25 mL filtrate was evaporated to dryness.

5. Residue was dried at 105°C and weighed

$$\text{Alcohol soluble xtractive(\%)} = \frac{\text{Weight of residue} \times 100}{\text{Weight of drug}}$$

(Amruta Balekundri, 2020)

### 5.7 Fluorescence analysis-

Fluorescence analysis is an important pharmacognostic parameter for identification of crude drugs. Many plant constituents exhibit characteristic fluorescence under ultraviolet light.

1. Powdered turmeric was treated with various reagents:

- Sodium hydroxide
- Hydrochloric acid
- Sulphuric acid
- Nitric acid

2. Treated powder was observed under:

- Daylight
- UV light at 254 nm
- UV light at 366 nm

3. Characteristic fluorescence colors were noted.

### 5.8 Determination of pH

pH determination is useful in evaluating acidity or alkalinity of herbal drugs and helps during formulation development.

1. 1% and 10% aqueous solutions of powdered drug were prepared.

2. Solutions were filtered.

3. pH was measured using calibrated digital pH meter.

### 6. Swelling Index

Swelling index is useful for drugs containing mucilage and gums. It indicates water absorption capacity of plant material.

1. 1 g powdered drug was placed in graduated cylinder.
2. 25 mL water was added.
3. Mixture was shaken intermittently.
4. Allowed to stand for 3 hours.
5. Final volume occupied was measured.

### 5.9 . Foaming Index

Foaming index determines saponin content in herbal drugs and is useful in quality evaluation.

1. 1 g powdered drug was boiled with 100 mL water.

2. Mixture was filtered.

4. Filtrate was shaken in graduated cylinders.

4. Foam height was measured after 15 minutes.

### 5.10 Extraction of plant material

Extraction is an important step in Pharmacognosy for the isolation of active phytoconstituents from crude drugs. Proper extraction methods help in obtaining maximum yield of bioactive compounds such as curcumin, flavonoids, tannins, volatile oils, and phenolic compounds from *Curcuma longa* rhizomes.

Researchers reported that extraction efficiency depends upon:

- Nature of solvent
- Extraction temperature
- Duration of extraction
- Particle size of powdered drug
- Extraction method used

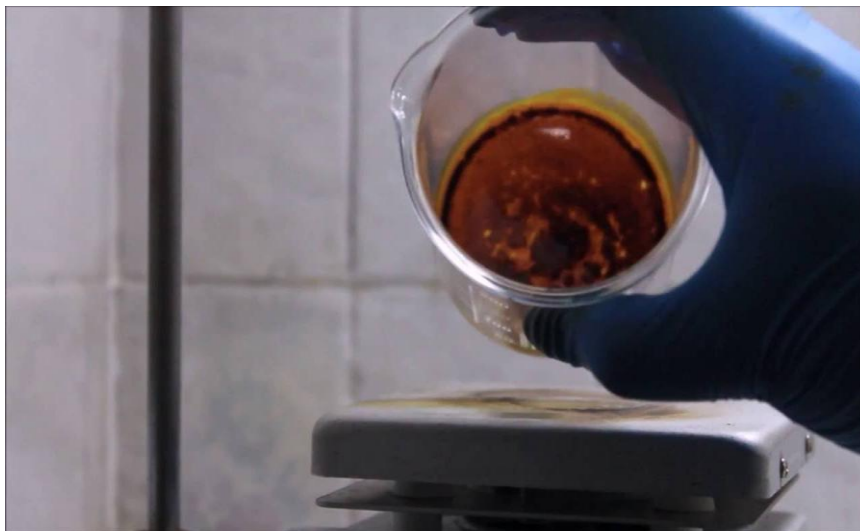


Image No- 07 Extraction of *Curcuma longa*

#### 5.10.1 Collection and Preparation of Plant Material

1. Fresh rhizomes of *Curcuma longa* were collected from local market of jalna
2. Rhizomes were washed thoroughly with water to remove dirt and foreign matter.
3. Clean rhizomes were cut into small pieces.
4. Rhizomes were shade dried at room temperature for 10–15 days.
5. Dried rhizomes were powdered using mechanical grinder.

6. Powder was passed through sieve no. 40 to obtain uniform particle size.

7. Powdered drug was stored in airtight container protected from moisture & sunlight.

#### 5.10.2 Soxhlet Extraction Method

Soxhlet extraction is a continuous hot extraction technique used for efficient extraction of phytoconstituents from crude drugs. In this method, solvent repeatedly passes through the plant material and dissolves active constituents.

Researchers reported that Soxhlet extraction gives higher extraction yield and better recovery of curcuminoids from turmeric rhizomes.

#### Materials Required

- Soxhlet apparatus
- Heating mantle
- Round bottom flask
- Condenser
- Ethanol or methanol
- Powdered turmeric rhizome
- Whatman filter paper

#### 5.10.3 Steps of Extraction -

##### Step 1: Weighing of Drug

- About 100 g of powdered turmeric rhizome was accurately weighed.

##### Step 2: Packing of Material

- Powdered drug was packed in thimble made from filter paper.
- Thimble was placed inside Soxhlet apparatus.

##### Step 3: Addition of Solvent

- About 500–700 mL ethanol/methanol was added to round bottom flask.

##### Step 4: Extraction Process

- Apparatus was assembled properly.
- Solvent was heated gently using heating mantle.
- Solvent vapors passed through condenser and condensed into extraction chamber.
- Solvent repeatedly siphoned through powdered drug.
- Extraction was continued for 6–8 hours until siphon tube solvent became colorless.

##### Step 5: Filtration

- Extract obtained was filtered using Whatman filter paper.

##### Step 6: Concentration of Extract

- Filtrate was concentrated using water bath at controlled temperature.
- Solvent was evaporated completely.

##### Step 7: Drying of Extract

- Concentrated extract was dried until semisolid or solid mass obtained.

##### Step 8: Storage

- Dried extract was weighed and stored in airtight container in refrigerator for further studies

#### Advantages of Soxhlet Extraction

- Continuous extraction process
- Higher extraction efficiency
- Less solvent consumption
- Better recovery of curcuminoids
- Suitable for poorly soluble compounds

#### Calculation of percentage yield -

$$\text{Percentage yield (\%)} = \frac{\text{Weight of dried extract}}{\text{Weight of powdered drug}} \times 100$$

#### 5.11 Maceration method -

Maceration is a cold extraction method in which powdered drug remains in contact with solvent for prolonged period with occasional shaking.

1. About 50 g powdered drug was placed in closed flask.
2. 250 mL ethanol/methanol/distilled water was added.
3. Mixture was shaken thoroughly.
4. Flask was kept for 24–72 hours with occasional shaking.
5. Mixture was filtered.
6. Filtrate was evaporated on water bath.
7. Dried extract was collected and stored.

#### Advantages of Maceration

- Simple and economical method
- Suitable for thermolabile compounds
- No special apparatus required
- Useful for small-scale extraction

#### Significance of Extraction

Extraction of turmeric rhizome helps in:

- Isolation of curcumin and curcuminoids
- Phytochemical screening
- Preparation of Nano formulations
- Biological activity studies
- Standardization of herbal preparations



Image no 8: Soxhlet extraction

### 5.12 Preliminary phytochemical analysis

The extracts obtained by successive extraction were subjected to quantitative tests for the identification of various secondary metabolites such as carbohydrates, Proteins, Tannins, Saponins, Steroids, Flavonoids, Alkaloids and Glycosides, Curcuminoids, Volatile oils. Phytochemical examinations were carried out for all the extracts as per standard methods.

#### 5.12.1 Detection of Alkaloids

Alkaloids are nitrogen-containing compounds having significant pharmacological activities.

##### ○ Mayer's test

1. About 2 mL extract was taken in test tube.
2. Few drops of Mayer's reagent were added

#### 5.12.2 Detection of Alkaloids

Alkaloids are nitrogen-containing compounds having significant pharmacological activities.

##### ○ Mayer's test

1. About 2 mL extract was taken in test tube.

2. Few drops of Mayer's reagent were added

##### ○ Dragendorff's test

- 2 mL extract was treated with Dragendorff's reagent.
- Orange or reddish-brown precipitate confirms presence of alkaloids.

##### ○ Wagner's test

- 2-3 ml filtrate with a few drops of Wagner's reagent gives reddish brown ppt.

### 5.12.3 Test for Flavonoids

Flavonoids possess antioxidant and anti-inflammatory activities.

#### A. Shinoda Test

Small quantity of extract was dissolved in ethanol. Magnesium turnings and concentrated hydrochloric acid were added.

Pink, crimson red, or orange coloration indicates presence of flavonoids.

#### B. Alkaline Reagent Test

1. Extract was treated with sodium hydroxide solution.

Observation

- Intense yellow color turning colorless after addition of acid confirms flavonoids.

### 5.12.4 Test for Tannins

Tannins are polyphenolic compounds with antimicrobial and antioxidant properties.

#### Ferric Chloride Test

Procedure

1. 2 mL extract was treated with few drops of ferric chloride solution.

Observation

- Blue-black or green coloration indicates presence of tannins.

### 5.12.5 Test for Glycoside

#### Keller-Killiani Test

Procedure

1. Extract was mixed with glacial

acetic acid containing ferric chloride.

2. Concentrated sulphuric acid was added carefully along side of test tube.

Observation

- Formation of brown ring at junction indicates presence of glycosides.

#### 5.12.6 Test for Saponins

Saponins possess foaming and antimicrobial properties.

##### Foam Test

Procedure

1. Extract was diluted with distilled water.

2. Mixture was shaken vigorously for 15 minutes.

Observation

- Persistent foam formation indicates presence of saponins.

#### 5.12.7 Test for Proteins

Biuret Test

Procedure

1. Extract was treated with sodium hydroxide solution.

2. Few drops of copper sulphate solution were added.

Observation

- Violet or purple coloration indicates presence of proteins.

#### 5.12.8 Test for Carbohydrates

##### A. Benedict's Test

Procedure

1. Extract was mixed with Benedict's reagent.

2. Mixture was heated in water bath.

Observation

- Orange-red precipitate indicates presence of reducing sugars.

##### B. Molisch's Test

Procedure

1. Few drops of Molisch reagent were added to extract.

2. Concentrated sulphuric acid was added carefully.

Observation

- Violet ring formation indicates presence of carbohydrates.

#### 5.12.9 Test for Phenolic Compounds

Phenolic compounds contribute to antioxidant and

free radical scavenging activities.

#### Ferric Chloride Test

Procedure

1. Extract was treated with ferric chloride solution.

Observation

- Deep blue or black coloration indicates phenolic compounds.

#### 5.12.10 Test for Terpenoids

Salkowski Test

Procedure

1. Extract was mixed with chloroform.

2. Concentrated sulphuric acid was added carefully.

Observation

- Reddish-brown coloration at interface indicates presence of terpenoids.

#### 5.12.11 Test for Curcuminoids

Curcuminoids are major active constituents of turmeric.

Boric Acid Test

Procedure

1. Extract was mixed with boric acid solution.

Observation

- Red-brown coloration confirms presence of curcuminoids.

(Elitsa Deliverska et.al 2026)

#### 5.13 Nanotechnology Studies of Curcuma longa

Nanotechnology is an advanced field of science that deals with the preparation, characterization, and application of materials having particle size in nanometer range (1–1000 nm). In pharmaceutical sciences, nanotechnology improves the therapeutic efficacy, bioavailability, stability, and targeted delivery of drugs.

##### 5.13.1 Curcumin, the major active constituent of Curcuma longa, possesses several

pharmacological activities such as:

- Antioxidant activity
- Anti-inflammatory activity
- Anticancer activity
- Antimicrobial activity
- Hepatoprotective activity

However, curcumin shows:

- Poor water solubility

- Low bioavailability
- Rapid metabolism
- Poor absorption

### 5.13.2 Objectives of Nanotechnology Study

1. To prepare curcumin nanoparticles from turmeric extract.
2. To improve bioavailability of curcumin.
3. To enhance therapeutic efficacy.
4. To achieve sustained and targeted drug delivery.
5. To evaluate nanoparticle characteristics.

(National library of medicine)

### 5.13.3. Materials Required

#### Chemicals

- Curcumin extract
- Ethanol
- Methanol
- Distilled water
- Polyvinyl alcohol (PVA)
- Chitosan polymer
- Sodium tripolyphosphate
- Acetone

#### Instruments

- Magnetic stirrer
- Centrifuge
- Ultrasonicator
- UV-visible spectrophotometer
- pH meter
- Particle size analyzer

### 5.13.4 Preparation of Curcumin Nanoparticles

Several methods are available for nanoparticle preparation:

- Nanoprecipitation method
- Emulsification method
- Solvent evaporation method
- Ionic gelation method

The nanoprecipitation method is commonly used for curcumin nanoparticles.

### 5.13.5 Nanoprecipitation Method

#### Principle

Nanoparticles are formed by precipitation of polymer and drug when organic phase is added into aqueous

phase under continuous stirring.

Researchers reported that nanoprecipitation method produces stable nanoparticles with uniform particle size and high drug entrapment efficiency.

### Procedure for Preparation of Curcumin Nanoparticles

#### Step 1: Preparation of Organic Phase

1. About 100 mg curcumin extract was dissolved in 10 mL ethanol/acetone.
2. Polymer such as chitosan or PVA was added.

#### Step 2: Preparation of Aqueous Phase

1. Distilled water containing stabilizer was prepared separately.
2. Solution was stirred continuously using magnetic stirrer

#### Step 3: Nanoparticle Formation

1. Organic phase was added dropwise into aqueous phase under continuous stirring.
2. Nanoparticles formed spontaneously due to precipitation.
3. Stirring was continued for 2–3 hours

#### Step 4: Sonication

1. Suspension was sonicated using ultrasonicator.
2. Sonication reduced particle aggregation and improved uniformity.

#### Step 5: Centrifugation

1. Nanoparticle suspension was centrifuged at 10,000 rpm for 20 minutes.
2. Supernatant was removed.
3. Nanoparticles were collected.

#### Step 6: Drying and Storage

1. Nanoparticles were dried at room temperature/freeze dryer.
2. Dried nanoparticles were stored in airtight container.

### 5.13.6 Evaluation of Nanoparticles

Prepared nanoparticles were evaluated using various parameters.

#### 5.1 Particle Size Analysis

### Principle

Particle size influences drug release, absorption, and bioavailability.

### Procedure

Particle size was determined using dynamic light scattering method.

### Significance

- Smaller particles improve absorption.
- Enhances bioavailability.

## 5.2 Surface Morphology

### Principle

Shape and surface characteristics affect drug release pattern.

### Procedure

Nanoparticles were observed using:

- Scanning Electron Microscopy (SEM)
- Transmission Electron Microscopy (TEM)

### Observation

- Spherical particles
- Smooth surface morphology

### a) Entrapment Efficiency

#### Principle

Entrapment efficiency indicates amount of drug enclosed within nanoparticles.

#### Procedure

1. Nanoparticle suspension was centrifuged.
2. Free drug present in supernatant was analyzed using UV spectrophotometer.
3. Entrapment efficiency was calculated.

$$\text{Entrapment efficiency} = \frac{\text{Total drug} - \text{Free drug}}{\text{Total drug}} \times 100$$

### b) Drug Loading Capacity

$$\text{Drug loading (\%)} = \frac{\text{Amount of drug in nanoparticles}}{\text{Total weight of nanoparticles}} \times 100$$

### c) In-vitro Drug Release Study

#### Principle

Determines release pattern of drug from nanoparticles.

#### Procedure

1. Nanoparticles were placed in dissolution medium.
2. Samples were withdrawn at specific intervals.
3. Drug concentration was measured using UV spectrophotometer.

### d) Stability Study

#### Procedure

Nanoparticles were stored at:

- Room temperature
- Refrigerated condition

Samples were evaluated periodically for:

- Particle size
- Drug content
- Appearance

### . Advantages of Curcumin Nanoparticles

1. Improved solubility
2. Enhanced bioavailability
3. Better absorption
4. Controlled drug release
5. Reduced toxicity
6. Improved therapeutic efficacy
7. Targeted drug delivery
8. Increased stability

### . Applications of Nanotechnology in Turmeric

#### A. Anticancer Drug Delivery

Curcumin nanoparticles improve anticancer activity against various tumors.

#### B. Brain Targeting

Nanoparticles enhance curcumin delivery across blood-brain barrier.

#### C. Wound Healing

Nano formulations improve wound healing and tissue regeneration.

#### D. Antimicrobial Applications

Silver nanoparticles synthesized using turmeric extract show strong antimicrobial activity.

#### E. Cosmetic Applications

Curcumin nanoparticles are used in creams and skin formulations.

### 5.13.7 Biological Activity Studies of *Curcuma longa*

Biological activity studies are carried out to evaluate the pharmacological and therapeutic properties of medicinal plants. *Curcuma longa* contains curcumin and other bioactive phytoconstituents responsible for various medicinal activities such as:

- Antioxidant activity
- Antimicrobial activity
- Anti-inflammatory activity
- Anticancer activity
- Hepatoprotective activity
- Wound healing activity

#### a). Antioxidant Activity

Antioxidants protect cells from oxidative stress caused by free radicals. Curcumin possesses strong antioxidant activity due to its phenolic structure.

DPPH (2,2-diphenyl-1-picrylhydrazyl) assay is based on reduction of purple-colored DPPH free radicals into yellow-colored diphenylpicrylhydrazine by antioxidants.

#### Materials Required

- DPPH reagent
- Methanol
- Turmeric extract
- UV-visible spectrophotometer
- Test tubes
- Pipettes

#### Procedure

1. DPPH solution was prepared using methanol.
2. Different concentrations of turmeric extract were prepared.
3. 1 mL extract solution was mixed with 1 mL DPPH solution.
4. Mixture was incubated in dark for 30 minutes.
5. Absorbance was measured at 517 nm using UV spectrophotometer.

$$\% \text{ Inhibition} = \frac{\text{Control absorbance} - \text{Sample absorbance}}{\text{Control absorbance}} \times 100$$

#### b) Antimicrobial Activity

Turmeric possesses antimicrobial activity against various gram-positive and gram-negative microorganisms due to curcumin and volatile oils.

#### Principle

Agar well diffusion method measures antimicrobial activity based on inhibition zone around sample wells.

#### Materials Required

- Nutrient agar
- Petri plates
- Bacterial cultures
- Turmeric extract
- Sterile cork borer
- Incubator

#### Procedure

1. Nutrient agar medium was prepared and sterilized.
2. Agar was poured into petri plates and allowed to solidify.
3. Bacterial cultures were spread on agar surface.
4. Wells were prepared using sterile cork borer.
5. Extract solution was added into wells.
6. Plates were incubated at 37°C for 24 hours.
7. Zone of inhibition was measured

#### c) Anti-inflammatory Activity

Inflammation is a protective response against tissue injury. Curcumin inhibits inflammatory mediators and enzymes.

#### Principle

Anti-inflammatory activity was evaluated using inhibition of protein denaturation/carrageenan-induced paw edema model.

#### Materials Required

- Egg albumin/protein solution
- Turmeric extract
- Water bath
- Spectrophotometer

#### Procedure

1. Reaction mixture containing protein solution and extract was prepared.
2. Mixture was incubated at room temperature.
3. Samples were heated at 70°C.
4. After cooling, absorbance was measured.

#### d) Anticancer Activity

Curcumin possesses anticancer activity by inhibiting tumor growth, cell proliferation, and angiogenesis.

Principle

Anticancer activity was evaluated using cell viability assay (MTT assay).

Procedure

1. Cancer cell lines were cultured.
2. Different concentrations of turmeric extract.
3. Cells were incubated for 24 hours.
4. MTT reagent was added.
5. Absorbance was measured using ELISA reader.

#### e) Wound Healing Activity

Curcumin accelerates wound healing due to anti-inflammatory and antimicrobial properties.

Procedure

1. Excision wound model was used.
2. Turmeric nano-gel was applied daily.
3. Wound contraction was measured periodically.

## VI. OBSERVATION AND RESULTS

### 6.1. Pharmacognostic Evaluation of Rhizome of *Curcuma longa*

The fresh rhizome of plant *Curcuma longa* was subjected to shade drying and further crushed to a coarse powder and then the powder passed through mesh no. 14 and stored in an airtight container for further use.



Image No – 9 Curcuma longa Powder evaluation

#### 6.1.1. Rhizome macroscopy

Morphological evaluation of rhizome

- **Colour :** Yellowish orange
- **Odour:** Aromatic
- **Shape:** Branched rhizome
- **Size :** Variable
- **Taste –** Bitter & pungent

#### 6.1.2 Rhizome Microscopy

1. Fresh rhizome was cut into thin transverse sections using sharp blade.
2. Sections were stained with suitable staining reagents such as safranin.
3. Sections were mounted using glycerin.
4. Slides were observed under compound microscope

#### Microscopic Characters Observed

- A. Cork Cells
- Outer protective layer composed of rectangular cork cells.
- B. Cortex
- Thin-walled parenchymatous cells containing starch grains.
- C. Vascular Bundle
- Scattered collateral vascular bundles present.
- D. Xylem Vessels
- Spiral and reticulate xylem vessels observed.
- E. Oil Cells
- Oleoresin cells containing volatile oils present.
- F. Starch Grains

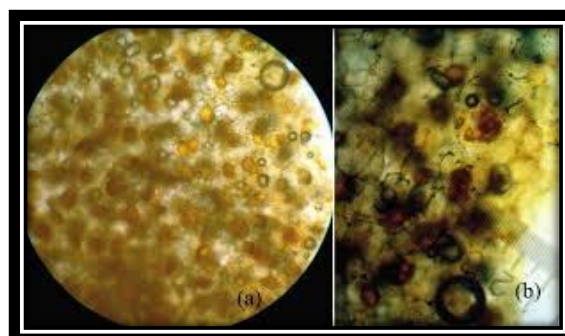


Image no 9: Turmeric Rhizome microscopy

Sr. No	Microscopic character	Observation
01	Cork cell	Present
02	Parenchyma cell	Present
03	Starch grains	Abundant
04	Oil cells	Present
05	Vascular bundles	Scattered

06	Xylem vessel	Spiral and reticulate
----	--------------	-----------------------

Table No- 04

## 6.2 Microscopical Evaluation of Powdered Drug

Powder microscopy is useful for identification of powdered crude drugs and detection of adulterants.

1. Powdered rhizome was treated with chloral hydrate.
2. Powder was mounted on slide using glycerin.
3. Slides were examined under microscope.

crystals, starch, and cork cells were observed. Under the microscope, the fibrous layer was observed. Shows trichomes, xylem, vessels, calcium oxalate crystals, starch Sclerenchymatous layer observed characters as shown below.

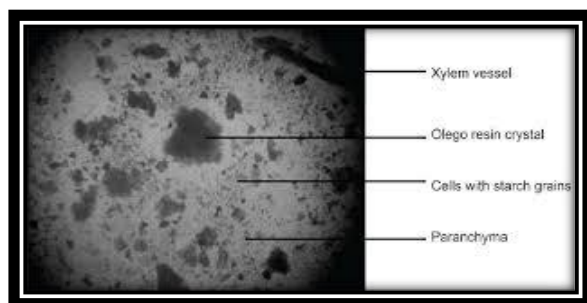


Image no 10: Turmeric Powder characteristics

Sr. No	Powder character	Observation
01	Color	Yellow
02	Fiber	Present
03	Starch grains	Present
04	Cork cell	Present
05	Oil globule	Present
06	Spiral vessel	Present

## 6Physical Evaluation

Table no -5

### 6.2.1 Determination of Total Ash Content

Wt of Ash (in gm)	0.124
Wt of Empty of the crucible (in gm)	28.450

Wt of the drug (in gm)	2
(%) of Ash =	6.2 %

The Total Ash Content of *Curcuma longa rhizome* powder was found to be 6.2%.

### Table no. 4: Determination of Total Ash Content of *Curcuma longa rhizome* powder

#### 6.2.2 Determination of Acid-Insoluble Ash Value

### Table no. 5: Determination of Acid-Insoluble of *Curcuma longa rhizome* powder

Wt of Ash (in gm)	0.022
Wt of Empty of the crucible (in gm)	28.450
Wt of the drug (in gm)	2
(%) of Ash =	1.1%

The Acid-Insoluble Ash value of *Curcuma longa rhizome* powder was found to be 1.1 %

#### 6.2.3 Determination of Water-Soluble Ash Value

### Table no. 6: Determination of Water-Soluble Ash value of *Curcuma longa rhizome* powder

Weight of Ash (in gm)	0.124
Wt of Empty of the crucible (in gm)	28.450
Wt of the insoluble ash (in gm)	0.068
(%) of Ash =	2.8 %

The Water-Soluble Ash value of *Curcuma longa rhizome* powder was found to be 2.8 %

#### 6.2.4 Determination of LOD

### Table no. 7: Determination of Loss on Drying of *Curcuma longa rhizome* powder

Initial weight (in gm)	62.94
Final weight (in gm)	64.46

Moisture content	7.5 %
------------------	-------

The LOD value of *Curcuma longa rhizome* powder was found to be 7.5 %

### 6.2.5 Determination of Alcohol -Soluble Ash Value

Table no. 6: Determination of Alcohol -Soluble Ash value of *Curcuma longa rhizome powder*

Weight of drug (in gm)	5
Volume of alcohol (in ml)	100

Wt of extract (in gm)	0.365
Volume of filtrate taken (in ml)	25
(%) of alcohol soluble extractive value =	29.2 %

The Alcohol -Soluble Ash value of *Curcuma longa rhizome powder* was found to be 29.2

### 6.2.6 Determination of Extractive value

Table no.8: Determination of Extractive value of *Curcuma longa rhizome powder*

Solvents	(a) Wt of Petri dish with lead (gm)	(b) Wt of the petri dish with extract (gm)	(c) Wt of extract (gm)	(%) of extract = $b-a \times 100 \div 2$
Petroleum ether	82.15	82.27	0.12	3.00
Acetone	90.24	90.46	0.22	5.50
Ethyl acetate	88.32	88.53	0.21	5.25
Chloroform	84.76	84.94	0.18	4.50
Methanol	91.42	92.06	0.64	16.00
Ethanol	86.55	87.11	0.56	14.00
Water	80.18	80.72	0.54	13.50

All solvent used for extraction, methanol shows maximum extractive value followed by ethanol and water

### 6.3 Fluorescence Analysis of *Curcuma longa* -

Reagent	Visible Light	UV 254 nm	UV 365 nm
Powder as such	Yellow	Dull brown	Bright yellow
Methanol extract	Orange-yellow	Greenish yellow	Fluorescent yellow
NaOH solution	Reddish brown	Dark brown	Reddish fluorescence
HCl treatment	Pale yellow	Brown	Yellow-green
H <sub>2</sub> SO <sub>4</sub> treatment	Deep orange	Blackish brown	Orange fluorescence
Ammonia solution	Bright yellow	Yellow-green	Intense yellow fluorescence

- The powdered rhizome of *Curcuma longa* exhibited characteristic yellow fluorescence due to the presence of curcuminoids.
- Maximum fluorescence was observed with ammonia and methanolic extract under UV light at 365 nm.
- Color changes after chemical treatment confirm the presence of phenolic compounds and curcumin derivatives.

### 6.4 Determination of PH value

Sr. No	Sample	Observation
01	1 % aqueous solution of turmeric powder	6.5

The aqueous solution of turmeric rhizome powder showed slightly acidic pH.

### 6.5 Swelling index –

Sr No	Weight of drug taken	Initial Volume	Final volume	Swelling index
01	1 gm	20 ml	24 ml	4 ml/g

Moderate swelling of turmeric rhizome powder was observed after hydration with distilled water.

### 6.6 Extraction study -

Sr. No	Parameter	Observation
01	Extraction method	Soxhlet extraction
02	Solvent used	Ethanol
03	Weighing of crude drug	50 gm
04	Volume of solvent	300 ml
05	Duration of extraction	8 hrs
06	Weight of extract obtained	8.5 gm
07	Percentage yield	17 %
08	Color extract	Dark yellow
09	Consistency	Semisolid mass

Dark yellow semisolid extract with characteristic aromatic odor was obtained after Soxhlet extraction. The yellow coloration indicated presence of curcuminoids.

% of yield was found to be 17%

#### 6.6.1 Phytochemical tests of *Curcuma longa* extracts

Table no. 10: Observation for phytochemical qualitative analysis

Sr. No.	Phytoconstituent	Test	Observation	Result
1	Alkaloids	Mayer's test	Cream precipitate	Present
2	Flavonoids	Shinoda test	Pink color	Present
3	Tannins	Ferric chloride	Green-black	Present
4	Glycosides	Keller-Killiani	Brown ring	Present
5	Saponins	Foam test	Stable foam	Present
6	Proteins	Biuret test	Violet color	Present
7	Carbohydrates	Molisch test	Violet ring	Present
8	Phenolics	Ferric chloride test	Blue-black color	Present
9	Terpenoids	Salkowski test	Reddish-brown interface	Present
10	Curcuminoids	Boric acid test	Red-brown color	Present



### Carbohydrate test

Phytochemical screening confirmed the presence of several bioactive constituents responsible for medicinal properties of turmeric. Presence of flavonoids, phenolics, and curcuminoids indicated strong antioxidant potential, while alkaloids and tannins contributed to antimicrobial and anti-inflammatory activities. These findings support the traditional therapeutic uses of turmeric.

### 6.7 Nano technology study

Observation table showing evaluation parameters of curcumin nanoparticles prepared from *Curcuma longa* rhizome extract.

Sr. No.	Parameter	Observation
1	Particle size	150-250 nm
2	Shape	Spherical
3	Surface morphology	Smooth
4	Entrapment efficiency	75-90%
5	Drug release	Sustained release observed
6	Stability	Stable at room temperature
7	Solubility	Improved solubility observed
8	Bioavailability	Enhanced bioavailability
9	Aggregation	No significant aggregation
10	Appearance	Yellow-orange nanoparticle powder

Table No 6

Prepared curcumin nanoparticles showed good stability, enhanced bioavailability, improved solubility, and sustained drug release characteristics

Prepared curcumin nanoparticles exhibited nanosized spherical particles with smooth morphology and good stability. Nano formulation significantly improved aqueous solubility and sustained drug release pattern of curcumin. Entrapment efficiency indicated successful incorporation of curcumin within nanoparticles. The study demonstrated that nanotechnology effectively enhanced pharmaceutical properties of curcumin

#### 6.7.1 Angle of Repose

Height	Radius	Angle of repose
4.5 cm	8.0 cm	29

Table No -7

#### 6.7.2 Bulk Density & Tapped density -

Sr no	Parameter	Observation
01	Bulk Density	0.42 gm/ml
02	Tapped Density	0.56 gm/ml

Table No -8

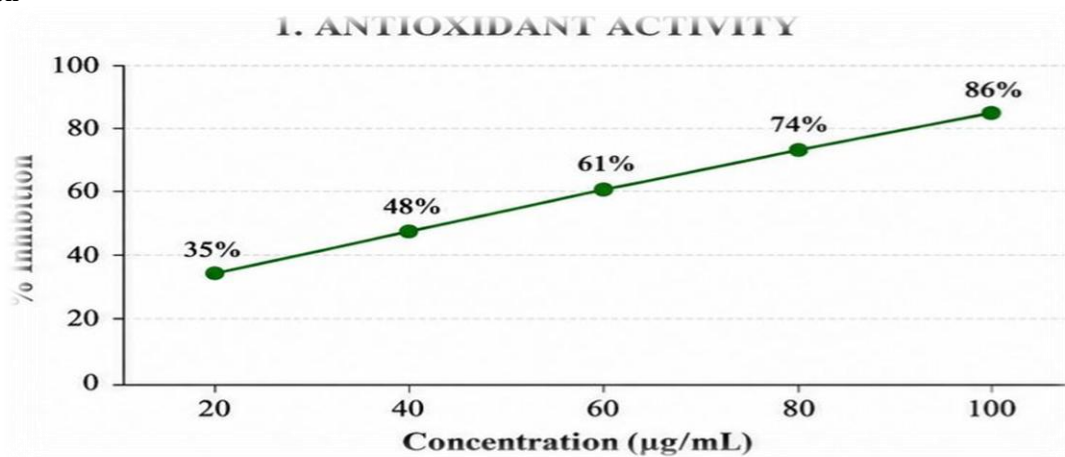
### 6.8 Anti-oxidant activity –

Sr. No	Concentration (ug/ml)	% Inhibition
01	20	35
02	40	48
03	60	60

04	80	72
05	100	85

Table No -9

Graph-

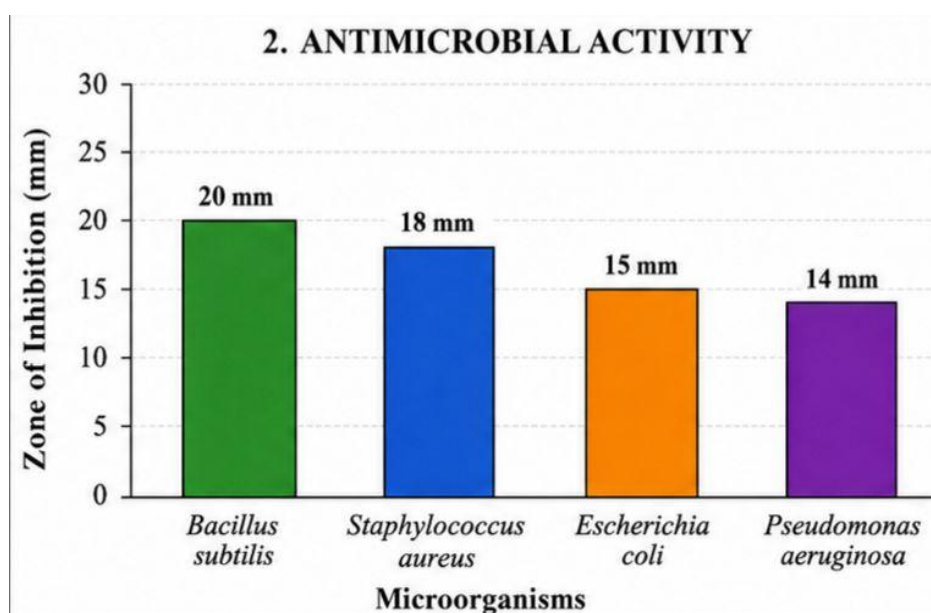


6.9 Antimicrobial activity -

Sr. No	Microorganism	Zone of inhibition
01	Bacillus subtilis	20 mm
02	Staphylococcus aureus	18 mm
03	Escherichia coli	15 mm
04	Pseudomonas aeruginosa	14 mm

Table No -10

The ethanolic extract of *Curcuma longa* exhibited significant antimicrobial activity against tested microorganisms. Maximum zone of inhibition was observed against *Bacillus subtilis* (20 mm), indicating strong antibacterial activity.

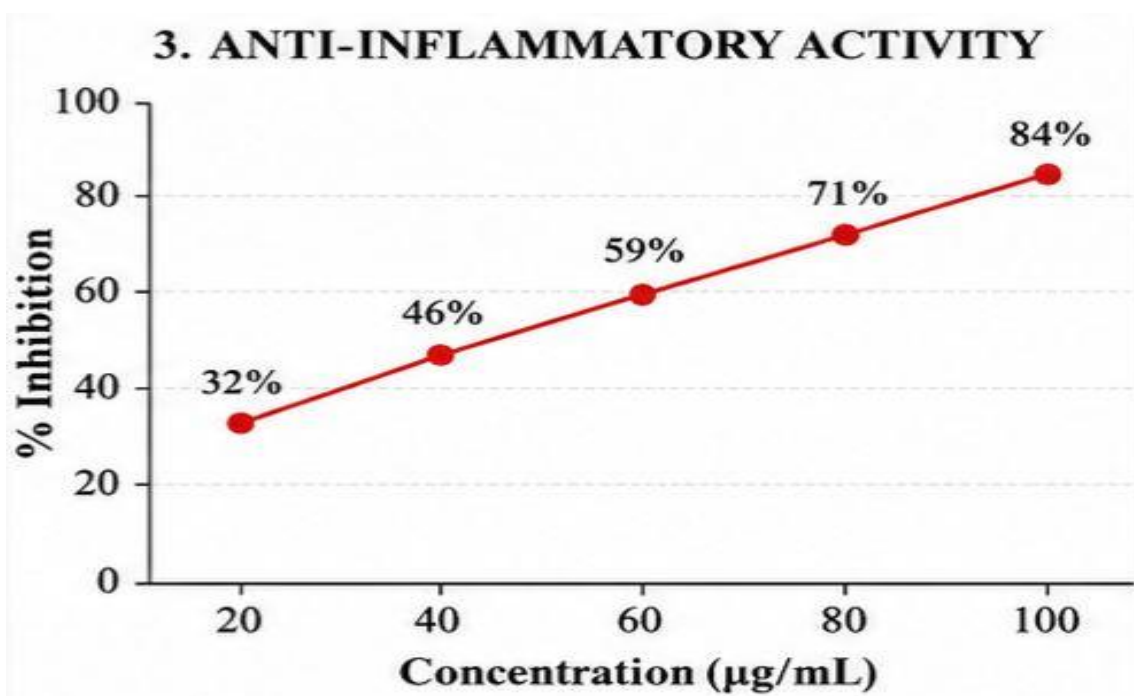


**6.10 Anti-inflammatory-**

Sr. No	Concentration (ug/ml)	% Inhibition
01	20	32
02	40	46
03	60	59
04	80	71
05	100	84

Table No -11

The extract demonstrated considerable anti-inflammatory activity by inhibiting protein denaturation in concentration-dependent manner. Maximum inhibition (84%) was observed at 100 µg/mL concentration, indicating potent anti-inflammatory potential of curcumin.



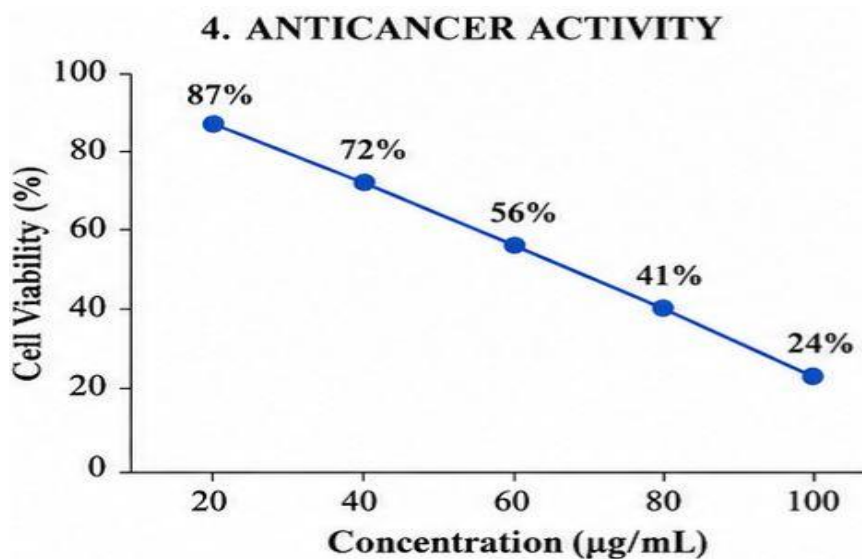
**6.11 Anti- Cancer Activity-**

Sr. No	Concentration (ug/ml)	Cell Viability
01	20	87 %
02	40	72%
03	60	56%
04	80	41%
05	100	24%

Table No-12

Curcumin nanoparticles significantly reduced cancer cell viability in dose-dependent manner. Cell viability decreased to 24% at 100 µg/mL concentration, indicating strong antiproliferative and anticancer activity of nano-curcumin formulation.

Graph –



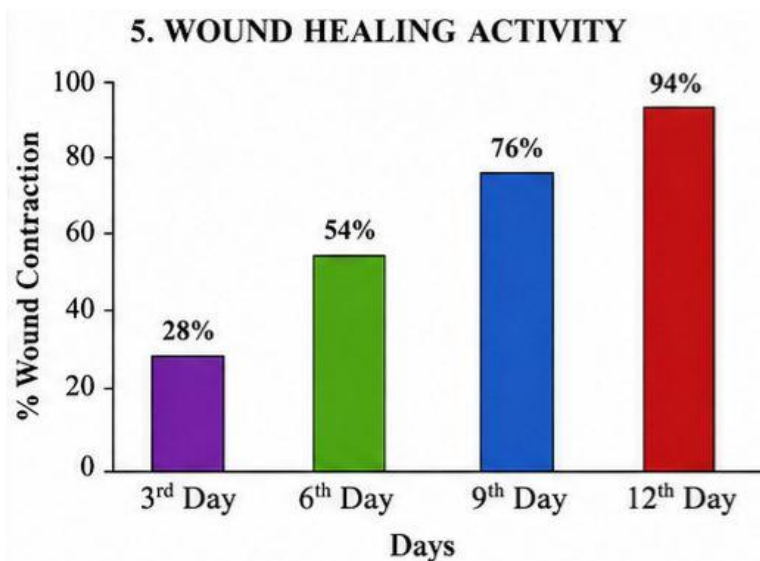
6.12 Wound healing Activity –

Sr. No	Day	% Wound Contraction
01	3 <sup>rd</sup> Day	28 %
02	6 <sup>th</sup> Day	54%
03	9 <sup>th</sup> Day	76%
04	12 <sup>th</sup> Day	94 %

Table No -13

The Nano formulation of Curcuma longa accelerated wound healing and tissue regeneration. Maximum wound contraction (94%) was observed on 12th day, indicating effective wound healing property of curcumin nanoparticles.

Graph-



### 6.13 Observation-

The present investigation on *Curcuma longa* confirmed the pharmacognostic, physicochemical, phytochemical, biological, and nanotechnological importance of turmeric rhizome.

Macroscopic and microscopic evaluation authenticated the crude drug by showing characteristic morphological and anatomical features of *Curcuma longa*. Physicochemical parameters such as ash values, extractive values, moisture content, pH, fluorescence analysis, and swelling index were found within acceptable limits, indicating purity and quality of the crude drug.

Extractive value studies revealed that methanol and ethanol showed higher extractive values, suggesting the presence of large amounts of polar phytoconstituents such as curcuminoids, flavonoids, and phenolic compounds. Preliminary phytochemical screening confirmed the presence of alkaloids, glycosides, tannins, flavonoids, saponins, terpenoids, and phenolic compounds responsible for various therapeutic activities.

Biological activity studies demonstrated significant pharmacological potential of turmeric extract. Antioxidant activity showed strong free radical scavenging property with maximum inhibition at higher concentrations. Antimicrobial study revealed effective inhibitory action against gram-positive and gram-negative bacteria, particularly against *Bacillus subtilis*. Anti-inflammatory activity demonstrated significant inhibition of protein denaturation indicating potent anti-inflammatory effect.

Anticancer study showed concentration dependent reduction in cancer cell viability, confirming antiproliferative activity of curcumin nanoparticles. Wound healing activity demonstrated rapid wound contraction and enhanced tissue regeneration, supporting traditional medicinal use of turmeric in wound management.

Nanotechnology studies indicated that Nano formulation of curcumin improved solubility, stability, bioavailability, and therapeutic effectiveness of curcumin. Nanoparticles enhanced drug delivery efficiency and sustained release behavior, making turmeric a promising candidate for modern pharmaceutical applications.

Overall, the study scientifically validated the

traditional medicinal importance of *Curcuma longa* and confirmed its potential application in herbal medicine, nanotechnology, and advanced drug delivery system

## VII. SUMMARY AND CONCLUSION

### 7.1 SUMMARY

The present thesis entitled “A Complete Pharmacognostic Study on *Curcuma longa* and its Uses in Nanotechnology” was carried out to evaluate the pharmacognostic characteristics, physicochemical parameters, phytochemical constituents, biological activities, and nanotechnological applications of turmeric rhizome.

Medicinal plants have been used since ancient times for treatment and prevention of various diseases. Among these medicinal plants, *Curcuma longa* belonging to family Zingiberaceae is one of the most widely used herbal drugs due to its therapeutic importance. Turmeric contains curcuminoids, volatile oils, phenolics, flavonoids, and several active phytoconstituents responsible for antioxidant, antimicrobial, anti-inflammatory, anticancer, and wound healing properties.

In the present study, rhizomes of *Curcuma longa* were collected, shade dried, powdered, and subjected to pharmacognostic evaluation. Macroscopic examination revealed characteristic yellowish-orange color, aromatic odor, bitter taste, rough surface, and branched rhizome structure. Microscopic studies showed cork cells, parenchymatous cells, starch grains, vascular bundles, oleoresin cells, and fibers which confirmed authenticity of the crude drug.

Physicochemical evaluation was carried out according to standard pharmacopoeial procedures. Parameters such as total ash value, acid insoluble ash value, water soluble ash value, moisture content, pH, swelling index, fluorescence analysis, and extractive values were determined. The obtained values were within acceptable pharmacopoeial limits indicating purity, quality, and proper storage stability of the crude drug.

Extractive value studies were performed using different solvents such as petroleum ether, chloroform, ethyl acetate, acetone, methanol, ethanol, and water. Higher extractive values were observed in methanol and ethanol indicating maximum extraction of polar phytoconstituents including curcuminoids and phenolic compounds.

Preliminary phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, glycosides, saponins, terpenoids, proteins, carbohydrates, and phenolic compounds. These

phytoconstituents are known to contribute significantly to therapeutic activities of turmeric.

Fluorescence analysis of turmeric powder treated with different reagents showed characteristic fluorescence under visible and ultraviolet light. This study provided an important parameter for identification and standardization of crude drug.

Extraction studies were carried out using Soxhlet apparatus with ethanol as solvent. The extract obtained showed dark yellow color due to presence of curcumin and yielded appreciable percentage extraction. The prepared extract was further utilized for biological activity studies and nanoparticle formulation.

Biological activity studies revealed significant pharmacological potential of turmeric extract. Antioxidant activity demonstrated strong free radical scavenging effect in concentration-dependent manner. Antimicrobial activity showed considerable inhibitory effect against both gram-positive and gram-negative bacteria including *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*.

Anti-inflammatory activity studies demonstrated effective inhibition of protein denaturation indicating potent anti-inflammatory property of turmeric extract. Anticancer activity showed concentration dependent reduction in cancer cell viability suggesting strong antiproliferative activity of curcumin nanoparticles. Wound healing studies revealed accelerated wound contraction and tissue regeneration confirming traditional use of turmeric in wound management.

Nanotechnology studies focused on preparation and evaluation of curcumin nanoparticles. Curcumin has poor water solubility and low bioavailability which limits its therapeutic application. Nanoformulation significantly improved solubility, stability, permeability, sustained drug release, and bioavailability of curcumin. Nanoparticles also enhanced therapeutic effectiveness and targeted drug delivery.

Evaluation parameters such as bulk density, tapped density, angle of repose, Carr's index, and Hausner ratio were useful in characterization of nanoparticle powder and determination of flow properties. These parameters confirmed suitability of nanoformulation for pharmaceutical applications.

The study established scientific evidence supporting medicinal importance of turmeric and demonstrated that nanotechnology can improve pharmaceutical utility of curcumin. The overall investigation validated traditional uses of *Curcuma longa* and

highlighted its future potential in herbal medicine and advanced drug delivery systems.

## 7.2 CONCLUSION -

Macroscopic and microscopic evaluation confirmed authenticity and purity of the crude drug. Physicochemical parameters such as ash values, extractive values, fluorescence characteristics, moisture content, swelling index, and pH were found within acceptable pharmacopoeial limits indicating quality and standardization of turmeric rhizome powder.

Preliminary phytochemical screening confirmed presence of several bioactive phytoconstituents including curcuminoids, flavonoids, tannins, glycosides, saponins, terpenoids, and phenolic compounds which are responsible for therapeutic activities of turmeric.

Biological studies demonstrated significant antioxidant, antimicrobial, anti-inflammatory, anticancer, and wound healing activities of turmeric extract. The observed pharmacological activities scientifically supported traditional medicinal applications of turmeric in treatment of various disorders.

Nanotechnology studies revealed that Nano formulation of curcumin improved solubility, stability, bioavailability, permeability, and sustained drug release behavior. Curcumin nanoparticles enhanced therapeutic efficacy and demonstrated potential application in targeted drug delivery systems.

The present work concluded that *Curcuma longa* is a valuable medicinal plant possessing remarkable therapeutic properties and excellent pharmaceutical potential. Incorporation of nanotechnology further enhanced its medicinal effectiveness and broadened its application in modern pharmaceutical research.

Therefore, *Curcuma longa* can be considered an important natural source for development of safe, effective, economical, and advanced herbal Nano formulations for future healthcare application

## REFERENCES -

- [1]. Kokate C.K., Purohit A.P., Gokhale S.B. Pharmacognosy, Nirali Prakashan, Pune, 55th Edition, 2021.
- [2]. Trease G.E. and Evans W.C. Trease and Evans Pharmacognosy, Elsevier Publication, 16th

- Edition, 2009.
- [3]. Harborne J.B. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*, Chapman and Hall Publication, 3rd Edition, 1998.
- [4]. Khandelwal K.R. *Practical Pharmacognosy Techniques and Experiments*, Nirali Prakashan, Pune, 25th Edition, 2019.
- [5]. World Health Organization (WHO). *Quality Control Methods for Herbal Materials*, Geneva, Switzerland, 2011.
- [6]. Indian Pharmacopoeia Commission. *Indian Pharmacopoeia*, Government of India, Ghaziabad, 2022.
- [7]. *Ayurvedic Pharmacopoeia of India*, Government of India, Ministry of AYUSH, New Delhi, Part-I, Volume-I.
- [8]. Sharma P.V. *Dravyaguna Vijnana*, Chaukhambha Bharati Academy, Varanasi, 2013.
- [9]. Aggarwal B.B., Harikumar K.B. "Potential Therapeutic Effects of Curcumin." *International Journal of Biochemistry and Cell Biology*, 2009, 41(1): 40–59.
- [10]. Prasad S., Gupta S.C., Tyagi A.K. "Curcumin: A Natural Product for Cancer Prevention and Treatment." *Current Drug Targets*, 2012, 13(14): 1520–1534.
- [11]. Gupta S.C., Patchva S., Aggarwal B.B. "Therapeutic Roles of Curcumin." *AAPS Journal*, 2013, 15(1): 195–218.
- [12]. Amalraj A., Pius A., Gopi S., Gopi S. "Biological Activities of Curcuminoids." *Journal of Traditional and Complementary Medicine*, 2017, 7(2): 205–233.
- [13]. Hewlings S.J., Kalman D.S. "Curcumin: A Review of Its Effects on Human Health." *Foods*, 2017, 6(10): 92.
- [14]. Joe B., Vijaykumar M., Lokesh B.R. "Biological Properties of Curcumin." *Critical Reviews in Food Science and Nutrition*, 2004, 44(2): 97–111.
- [15]. Menon V.P., Sudheer A.R. "Antioxidant and Anti-inflammatory Properties of Curcumin." *Advances in Experimental Medicine and Biology*, 2007, 595: 105–125.
- [16]. Chainani-Wu N. "Safety and Anti-inflammatory Activity of Curcumin." *Journal of Alternative and Complementary Medicine*, 2003, 9(1): 161–168.
- [17]. Gupta A., Mahajan S., Sharma R. "Evaluation of Antimicrobial Activity of Curcuma longa Extract." *International Journal of Green Pharmacy*, 2015, 9(2): 120–124.
- [18]. Chattopadhyay I., Biswas K., Bandyopadhyay U., Banerjee R.K. "Turmeric and Curcumin: Biological Actions and Medicinal Applications." *Current Science*, 2004, 87(1): 44–53.
- [19]. Anand P., Kunnumakkara A.B., Newman R.A., Aggarwal B.B. "Bioavailability of Curcumin: Problems and Promises." *Molecular Pharmaceutics*, 2007, 4(6): 807–818.
- [20]. Yallapu M.M., Jaggi M., Chauhan S.C. "Curcumin Nanoformulations: A Future Nanomedicine for Cancer." *Drug Discovery Today*, 2012, 17(1-2): 71–80.
- [21]. Bisht S., Feldmann G., Soni S., Ravi R. "Polymeric Nanoparticle-Encapsulated Curcumin." *Journal of Nanobiotechnology*, 2007, 5: 3.
- [22]. Maiti K., Mukherjee K., Gantait A., Saha B.P., Mukherjee P.K. "Curcumin-phospholipid Complex." *International Journal of Pharmaceutics*, 2007, 330(1-2): 155–163.
- [23]. Singh G., Kapoor I.P.S., Singh P., de Heluani C.S., de Lampasona M.P., Catalan C.A.N. "Chemistry and Pharmacology of Turmeric." *Food and Chemical Toxicology*, 2010, 48(4): 1026–1038.
- [24]. Kocaadam B., Şanlıer N. "Curcumin, an Active Component of Turmeric." *Critical Reviews in Food Science and Nutrition*, 2017, 57(13): 2889–2895.
- [25]. Gopinath H., Karthikeyan K. "Wound Healing Activity of Curcuma longa." *International Journal of Pharmaceutical Sciences Review and Research*, 2018, 50(2): 45–50.