FORMULATION, PHYSICOCHEMICAL CHARACTERIZATION, AND BIOLOGICAL EVALUATION OF A *CURCUMA LONGA*-BASED HERBAL OINTMENT FOR WOUND HEALING APPLICATIONS

Swapna battala*[1], Nemali Navya[2], Sama Nirmala[3], Halwale Neha[4], Saye Sangeetha[5]

1*****Associate professor, Department of pharmaceutical chemistry, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth(Deemed to be university),maisammaguda,Secunderabad,500100,Telangana,India

2. B.pharm 4th year student, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth,maisammaguda,Secunderabad,500100,Telangana,India

3. B.pharm 4th year student, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth,maisammaguda,Secunderabad,500100,Telangana,India

4. B.pharm 4th year student, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth,maisammaguda,Secunderabad,500100,Telangana,India

5. B.pharm 4th year student, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth,maisammaguda,Secunderabad,500100,Telangana,India

*Corresponding Author:
Swapna battala*,

*****Associate professor, Department of pharmaceutical chemistry, Malla Reddy institute of pharmaceutical sciences,Malla Reddy viswavidyapeeth(Deemed to be university),maisammaguda,Secunderabad,500100,Telangana,India

ABSTRACT

The present study was undertaken to formulate and evaluate a herbal healing ointment using *Curcuma longa* (turmeric) as the primary active ingredient, owing to its well-known antimicrobial, anti-inflammatory, and antioxidant properties. The aim was to develop a safe, stable, and effective topical formulation for the treatment of wounds and minor skin infections. The ointment was prepared by the fusion method using turmeric powder, coconut oil as the base, beeswax as a stiffening agent, and methylparaben and propylparaben as preservatives.

The prepared formulation was evaluated for various physicochemical parameters including colour, odour, consistency, pH, viscosity, spreadability, extrudability, washability, loss on drying, and solubility. The ointment exhibited a smooth, homogeneous semisolid texture with no phase separation and a characteristic yellow colour. The pH of the formulation was found to be in the range of 6.4–6.8, indicating compatibility with skin. Good spreadability and extrudability were observed, suggesting ease of application and better patient compliance.

Stability studies were conducted at different temperature conditions (4°C, 25°C, and 37°C) over a period of four weeks, and no significant changes in physical properties were observed, confirming the stability of the formulation. The antibacterial activity was assessed using the agar well diffusion method against *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*. The formulation showed significant antibacterial activity, particularly against *Staphylococcus aureus*. Anti-inflammatory activity evaluated by the protein denaturation method revealed concentration-dependent inhibition, with maximum inhibition observed at higher concentrations.

In conclusion, the developed herbal ointment demonstrated satisfactory physicochemical properties along with notable antimicrobial and anti-inflammatory activities. The formulation shows potential as a safe, effective, and cost-efficient topical therapeutic option for wound healing and management of minor skin infections. Further in vivo and clinical studies are recommended to confirm its efficacy.

Key Words: *Curcuma longa*, Herbal ointment, Curcumin, Fusion method, Antibacterial activity, Anti-inflammatory activity, Topical formulation

INTRODUCTION

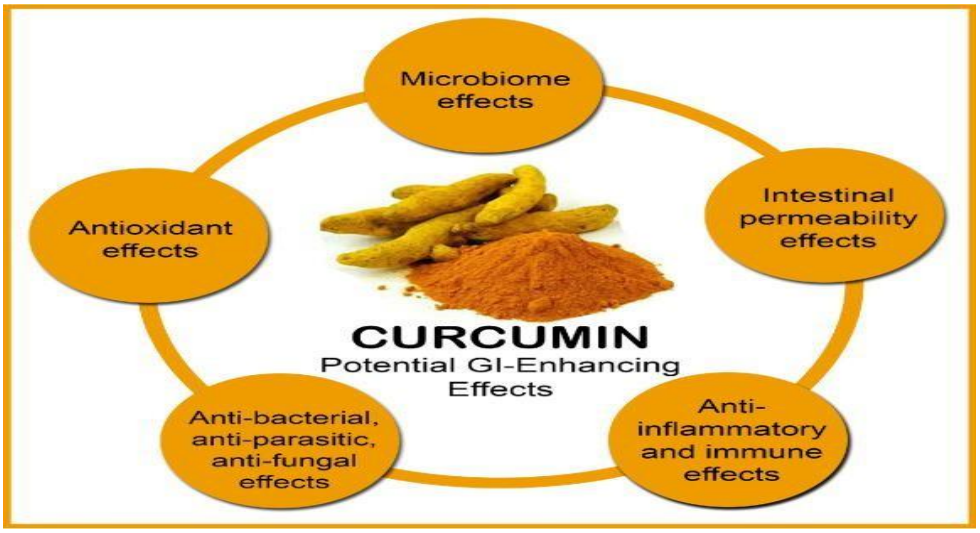
Herbal medicines have been an integral part of traditional healthcare systems and continue to gain importance due to their therapeutic efficacy, safety, and cost-effectiveness. Topical herbal formulations such as ointments are commonly used for the treatment of skin disorders, wounds, and infections. Ointments are semisolid dosage forms intended for external application to provide protective, antiseptic, soothing, or healing effects.

The Therapeutic Potential of Turmeric:

Turmeric (*Curcuma longa*), a well-known medicinal plant recognised in traditional medicine for its function in wound healing and treating skin infections, is the main active ingredient in this formulation. Curcumin, the main bioactive component of turmeric, is primarily responsible for its effectiveness. Curcumin possesses a unique combination of biological activities:

- **Anti-inflammatory:** Diminishes redness and swelling at the injury site.
- **Antimicrobial:** Prevents the growth of bacteria and fungi, reducing the risk of infection.

- **Antioxidant:** Promotes quicker tissue repair by shielding cells from oxidative stress.



Role of the Ointment Base and Additives:

A successful topical formulation requires a stable base to deliver the active ingredients effectively:

- **Coconut Oil:** Used as the primary ointment base, it provides essential emollient properties to keep the skin hydrated. It also contains lauric acid, which contributes inherent antimicrobial activity to the formulation.
- **Beeswax:** This natural wax acts as a stiffening agent. It is incorporated to ensure the ointment reaches the desired semisolid consistency and remains stable under various storage conditions.
- **Methylparaben & Propylparaben:** These are preservatives used to prevent microbial contamination & improve product stability.

The present study aims to formulate and evaluate a herbal healing ointment using natural ingredients for safe and effective topical application.

Many drugs that are meant to be applied topically to intact or damaged skin or mucous membranes are administered in semisolid form, such as ointments, creams, salves, pastes, and so forth, and are mostly employed as emollients or skin protectors. The purpose of modern ointments is the same as that of traditional ointments, but they also transfer the drugs into the bloodstream. They are therefore employed as:

a. Epidermatic: Designed to be applied to the epidermis.
b. Endodermatic—designed to target the skin's deeper layers.
c. Diadermic: This method delivers drugs into the bloodstream (systemic circulation) by penetrating deeply into the skin [1].

Viscous semisolid formulations administered externally are called ointments. They are applied topically to different parts of the body. They include the skin and mucous membranes of the nose, vulva, chest, anus, and eyes (including eye ointment). For dry skin, ointments are helpful.

Because there aren't many compounds other than the fundamental oil or fat, they have a lower chance of irritation and discomfort [2].

Ointments are typically offered in both medicated and unmedicated versions.

1. Medicated ointments: These are employed as preventative, therapeutic, or protective measures and contain API.

2. Unmedicated ointments: These include lubricating, emollient, or protecting properties [3].

OINTMENT TYPES [4]**-**

Ointments can be categorised in one of two ways:

1) Based on their penetrability and therapeutic benefits.
2) With regard to their therapeutic uses.

1. Classification of ointment based on penetration qualities-

- **a. Epidermic ointments-** these have a local effect when applied to the epidermis. They are not accepted. These ointments are frequently used as parasiticides, antiseptics, protectives, and local anti-infectives.
- **b. Endodermic ointments-** These ointments are made to target the skin's deeper layers. After being partially absorbed, they function as stimulants, emollients, and local irritants.
- **c. Diadermic ointments-** These ointments are made to release drugs that have systemic effects by penetrating deeply into the skin.

2. Classification of ointment based on therapeutic uses-

- **a. Antibiotic Ointments-** Antibiotic ointments are used to eradicate germs and bacteria. Chlorotetracycline, neomycin, bacitracin, and other antibiotics are used.
- **b. Antifungal Ointments-** The purpose of these ointments is to stop fungi from killing one another. Antifungal medications like nystatin, salicyclic acid, and benzoic acid are commonly used.
- **c. Anti-inflammatory Ointments-** These ointments are used to treat pruritic, allergic, and inflammatory skin conditions. Anti-inflammatory medications such hydrocortisone, its acetate, and betamethasone valerate are commonly used.
- **d. Antipruritic Ointments-** These ointments are used to reduce itching. Two popular antipruritics are coal tar and benzocaine.
- **e. Astringent Ointments-** These ointments cause the skin to shrink and lessen secretions. Tannic acid, acetic acid, zinc oxide, and calamine are common astringents found in ointment bases.
- **f. Antieczematous Ointments-** These ointments are designed to prevent skin vesicles from leaking and excreting. Among the drugs that are frequently used with ointment bases are hydrocortisones, ichthammol, coal tar, and salicylic acid.
- **g. Keratolytic Ointments-** These ointments are used to remove or soften the horny layer of skin. Medicines that remove keratin include cetrimide, salicylic acid, and resorcinol.

OINTMENT IDEAL CHARACTERISTICS [5]:

The following are some of the ideal ointment qualities:

- It must not obstruct the healing of wounds and be compatible and inactive. • Release the drug at the application site in an efficient manner.
- Using it with over-the-counter drugs is safe.
- Make use of the fewest possible components.
- The substance remains stable in storage, and compounding is easy.
- Inexpensive and easy to transport [5].

ADVANTAGES [2]:

- Simple to give to unconscious patients who have difficulty swallowing.
- By preventing needless medication exposure to non-target locations, they enable site-specific drug delivery to the afflicted area, hence preventing side effects.
- They evade the first-pass metabolism of the medication.
- They are easier to handle and more chemically stable than liquid dosage forms.
- They are suitable dose forms for drugs that taste bitter [2].

BIOLOGICAL SOURCE & ITS CONSTITUENTS:

Curcuma longa, also called turmeric, is a perennial herb made from the dried roots and rhizomes of the Zingiberaceae family of plants. A yellow powder is produced by the rhizome, which is the plant's therapeutic component. The dried Curcuma longa is the source of turmeric, which gives curry powder its characteristic yellow hue. Turmeric's primary ingredient, curcumin, has the ability to heal wounds [6]. It is also known as curcumin in the Arab world, Indian saffron, Haridra (Sanskrit, Ayurvedic), Jianghuang (yellow ginger in Chinese), and Kyoo or Ukon (Japanese)[7]. In Iran, China, and India, curcumin has long been used in traditional medical systems [8]. Countries including India, Sri Lanka, Myanmar, Thailand, Malaysia, Indonesia, China, and several African nations are home to large populations of the plant "Curcuma longa"[9]. Asian cuisines have traditionally utilised turmeric for its flavour and colour, while Chinese and Ayurvedic medicine has long employed it for its anti-inflammatory properties to treat conditions including jaundice, menstrual issues, haematuria, bleeding, and colic. It is used for a wide range of medical disorders and is recognised by both the Chinese pharmacopoeia and the pharmacopoeias of other Asian nations, including Korea and Japan. In China, it is used to treat wounds, sore throats, joint inflammation, viral hepatitis, urticaria, and skin allergies [10].

Turmeric is composed of curcumin (diferuloylmethane), demethoxycurcumin, and bisdemethoxycurcumin, as well as volatile oils (tumerone, atlantone, and zingiberone), carbohydrates, proteins, and resins. The curcuminoid complex is also known as Indian saffron. Curcumin is a lipophilic polyphenol that is nearly insoluble in water [7], although it is stable at the acidic pH of the stomach [11]. Curcumin, a primary curcuminoid, is extracted from the spice turmeric. Curcumin is a naturally occurring yellow polyphenolic compound with potent antibacterial, anti-inflammatory, antioxidant, and wound-healing qualities. As a result, it is

Frequently used to treat conditions including skin ageing, psoriasis, acne, inflammation, skin damage, skin cancer, dermatitis, rheumatism, diabetic ulcers, anorexia, cough, and sinusitis. Turmeric's yellow hue is caused by curcumin. Curcumin, which makes up 3–4% of turmeric's chemical composition, is diferuloyl methane. Curcumin protects skin from UVB damage [12]. However, there hasn't been much research done on the systemic and local effects of turmeric and its components, as well as their possible clinical use. More research is therefore required. Since all of the topical antimicrobial medicines now on the market have disadvantages, the hunt for an optimum or nearly ideal topical treatment for burn victims is still underway. For many years, turmeric/curcumin has been used in both home remedies and commercial cosmetic formulations with no discernible harmful effects. The chemical formula for curcumin, which has been extracted and made in a lab, is 1, 7-bis (4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5-Dione. Therefore, the current study was carried out specifically to assess the potential benefits of turmeric as a topical ointment with antimicrobial, anti-inflammatory, antibacterial, and wound-healing properties [13].

Curcumin enhances the migration and re-epithelialization of cells, including macrophages, fibroblasts, and myofibroblasts[14]. By specifically blocking the arachidonic acid pathway, curcumin reduces pain and inflammation [14]. The pro-inflammatory enzyme 5-LOX is inhibited and its expression is down-regulated by curcumin. Additionally, it causes the down-regulation of several inflammatory cytokines, including interferon, TNF, IL-1, IL-6, IL-8, and certain other chemokines [15, 16]. Sonali P. Mahaparale et al. Ijppr is cited.Human, 2019; Vol. 16 (3): 419-427 (42)

MATERIALS AND METHODS

The preparation of the herbal healing ointment followed a structured laboratory process to ensure the stability and therapeutic integrity of the natural ingredients

Materials used:

The formulation utilized a specific combination of active and excipient materials to achieve a functional semisolid dosage form:

- **Active Ingredient:** Turmeric powder *(Curcuma longa),* selected for its curcumin content which provides anti-inflammatory and antimicrobial properties.
- **Ointment Base:** Coconut oil, which serves as a natural emollient and provides an additional antimicrobial layer via lauric acid.
- **Stiffening Agent:** Beeswax, incorporated to manage the consistency and melting point of the final product.
- **Laboratory Equipment:** Porcelain dish, water bath (for controlled heating), glass rod (for stirring), weighing balance, filter cloth, and sterilized ointment containers.

MASTER FORMULA: (For 20 grams)

S.NO	Ingredients	Quantity	Role
1.	Turmeric Powder	1gm	Active ingredient (Anti-inflammatory/ Anti-microbial)
2.	Coconut oil	15.5gm	Ointment base & Emollient
3.	Beeswax	3gm	Stiffening agent
4.	Methylparaben	0.1gm	Preservative
5.	Propylparaben	0.01gm	Preservative

INSTRUMENTS & GLASSWARE USED:

S.NO	Instruments/ Glassawares	Purpose in formulation
1.	Digital analytical balance	Weighing of raw materials
2.	Water bath	Controlled melting of base
3.	Porcelain dish	Preparation of ointment base
4.	Glassrod	Stirring & Homogenization
5.	Thermometer	Monitoring temperature
6.	pH meter	Evaluation of pH
7.	Brookfield viscometer	Viscosity measurement
8.	Measuring cylinder	Measuring liquid ingredients
9.	Filter cloth	Removal of coarse particles
10.	Ointment container	Storage of final product

Method of preparation: The Fusion Method

The formulation of the herbal healing ointment was executed using the fusion method, a process where components are melted together and cooled to form a uniform semisolid. This method ensures that the active herbal ingredients are evenly dispersed within the protective base.

1. **Preparation of the Oil Base:** A measured quantity of 15.5 g of coconut oil was placed into a clean porcelain dish. The dish was then placed on a water bath and heated gently.
2. **Incorporation of the Stiffening Agent:** Once the coconut oil reached an appropriate temperature, 3 g of beeswax was added to the heated oil. The mixture was stirred continuously with a glass rod until the beeswax was completely melted, ensuring a liquid, homogenous base.
3. **Addition of Preservatives:** The accurately weighed quantities of methylparaben and propylparaben were added to the molten oil phase after complete melting of beeswax. The mixture was stirred continuously to ensure complete dissolution and uniform distribution of the preservatives in the base.
4. **Active Ingredient Integration:** The porcelain dish was removed from the heat source. 1 g of turmeric powder was then added slowly to the molten mixture. Constant and vigorous stirring was maintained during this step to ensure the uniform dispersion of the turmeric and to prevent the formation of lumps.
5. **Refinement and Filtration:** To ensure the final product was smooth and free of coarse particles or un-dissolved matter, the molten ointment was filtered through a clean filter cloth.
6. **Cooling and Solidification:** The refined, molten preparation was immediately poured into sterilized ointment containers. The formulation was then left undisturbed to cool and solidify at room temperature, resulting in a smooth, yellow, semisolid ointment.

EVALUATION PARAMETERS

1. COLOUR & ODOUR:

These are determined by the visual examination.

2. CONSISTENCY:

Smooth & no grittiness are observed.

3. pH:

The pH of the ointment has been determined with the help of digital pH meter. The ointment solution has been prepared by using 100 ml distilled water & set aside for 2 hrs.[17].

4. LOSS ON DRYING:

Loss on drying is determined to place the ointment in the petri-dish on a water bath & dried at the temperature 105ºC [18].

$$\text{Percentage loss on drying} = 100 \times (Wt - MW) / Wt$$

5. VISCOSITY:

The viscosity was determined by CAP- 2000 Brookfield viscometer. The test sample was taken in a clean and dry 250 ml beaker and the viscosity of the test sample was determined by the standard operating procedure of Viscometer by using spindle nos. 1 to 4. Each spindle was used for finding the viscosity of the sample at speeds of 0.3, 0.6, 1.5,3,6,12,30 and 60r.p.m. respectively. Their rheological characteristics were also tested at 250 C using Brookfield viscometer [19].

6. SPREADABILITY:

The spreadability is determined by placing the excess sample in between two slides which were compressed to uniform thickness by placing a definite weight for a specific time. The time required to separate the two slides was measured as spreadability. As less time required for separation of two slides results in better spreadability. Spreadability was calculated by the following formula:

$$S=M \times L/T$$

Where,

S= Spreadability

M= Weight tide to the upper slide

L= Length of glass slide

T= Time taken to separate the slides

7. EXTRUDABILITY:

In the recent study, the method adopted for evaluating ointment formulation for extrudability was based upon the quantity in percentage ointment extruded from the tube on the application of finger pressure. More quantity extruded better was extrudability. The formulation understudy was filled in a clean, lacquered aluminum collapsible 5 gm tube with a nasal tip of 5 mm opening and applied the pressure on the tube with the help of a finger. Tube extrudability was then determined by measuring the amount of cream extruded through the tip when pressure was applied on a tube [20].

8. SOLUBILITY:

Soluble in boiling water, & miscible with ethanol, ether & chloroform.

9. WASHABILITY:

The ointment was applied to the skin and then ease the extent of washing with water was checked.

10. NON-IRRITANCY TEST:

The ointment has been applied to the skin of human being & observed for the effect.

11. STABILITY STUDIES:

The international conference on harmonization (ICH) harmonized tripartite guidelines on stability testing of new drug substances and the product was issued on 27th October 1993[21]. The physical stability test of the herbal ointment was carried out for four weeks at various temperature conditions like 4ºC, 25ºC, and 37ºC. The ointment was found to be physically stable at different temperature i.e. 4ºC, 25ºC, 37ºC [22, 23].

RESULTS AND DISCUSSION

1. ORGANOLEPTIC EVALUATION:

The physical look and sensory qualities of the prepared herbal medicinal ointment were assessed. Table 1 displays the results.

Tabel 1: Organoleptic Properties of the Formulated Ointment

S.NO	Parameter	Observation
1.	Colour	Yellow
2.	Odour	Characteric odour of turmeric
3.	Appearance	Smooth semisolid
4.	Texture	Homogeneous, non-gritty
5.	Phase separation	Absent

The formulation showed consistent consistency without lump formation or phase separation, suggesting that the contents were properly mixed and compatible.

2. PHYSICOCHEMICAL EVALUATION:

Physicochemical analysis of the ointment was conducted, and Table 2 summarises the findings.

Table 2: Physicochemical Parameters

S.NO	Parameter	Result
1.	pH	6.4 - 6.8
2.	Spreadability	Good
3.	Extrudability	Easily extrudable
4.	Washability	Easily washable
5.	Loss on drying	< 5%
6.	Solubility	Miscible in organic solvents

Good spreadability guarantees ease of administration and higher patient compliance; the lack of grittiness shows uniform dispersion of turmeric powder; the pH of the formulation was found to be within the permissible skin range, suggesting little discomfort upon application.

3. VISCOSITY AND RHEOLOGICAL BEHAVIOR:

It was determined that the produced ointment's viscosity was appropriate for topical use. The formulation showed good rheological behaviour and maintained a semisolid consistency, both of which are necessary for appropriate retention at the application location.

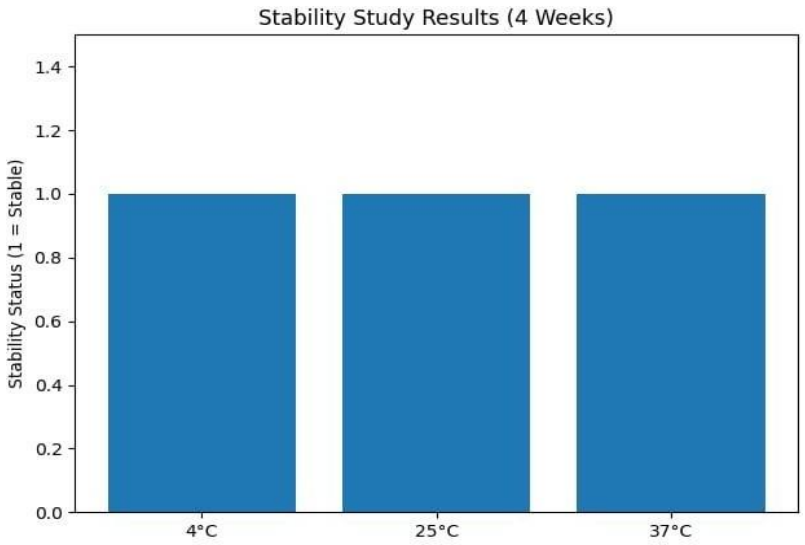
4. STABILITY STUDIES:

For four weeks, the formulation was tested for stability at three distinct temperatures: 4°C, 25°C, and 37°C.

Tabel 3: Stability study observations

S.NO	Parameter	4° C	25° C	37° C
1.	Colour change	No change	No change	No change
2.	Odour	No change	No change	No change
3.	Consistency	Stable	Stable	Stable
4.	Phase separation	Absent	Absent	Absent

Over the course of the investigation, no appreciable physical changes were noticed, suggesting that the formulation was stable.



5. ANTIBACTERIAL ACTIVITY:

Using the agar well diffusion method, the antibacterial activity of the prepared herbal healing ointment was assessed against three common skin pathogens: Pseudomonas aeruginosa, Escherichia coli, and Staphylococcus aureus. Gentamicin (10 µg) was used as the standard reference drug, and the ointment base served as the negative control. Table 4 displays the findings.

Table 4. Zone of Inhibition of the Formulated Ointment Against Selected Microorganisms

S.No	Test Organism	Formulated Ointment (Mm)	Gentamicin (Mm)	Control – Base (Mm)
1.	*Staphylococcus aureus*	14 ± 0.5	20 ± 0.4	2 ± 0.2
2.	*Escherichia coli*	12 ± 0.6	18 ± 0.3	1± 0.1
3.	*Pseudomonas aeruginosa*	17 ± 0.5	1± 0.1	1 ± 0.1

Values are expressed as Mean ± SD (n = 3).

All examined organisms showed detectable antibacterial action from the prepared ointment, with Staphylococcus aureus showing the largest zone of inhibition (14 ± 0.5 mm). Escherichia coli showed moderate inhibition (12 ± 0.6 mm), but Pseudomonas aeruginosa showed relatively less activity (10 ± 0.4 mm).

The simpler cell wall structure of the Gram-positive bacterium Staphylococcus aureus, which lacks the outer lipopolysaccharide membrane that functions as a permeability barrier in Gram-negative bacteria, may be the reason for its increased sensitivity. The formulation's broad-spectrum antibacterial capability is demonstrated by its diminished but noteworthy efficacy against Pseudomonas aeruginosa and Escherichia coli.

Significantly larger inhibitory zones (17–20 mm) were produced by the common medication gentamicin, which validated the experimental procedure and confirmed the microbial strains' susceptibility. The ointment base showed very little inhibition (1-2 mm), indicating that Curcuma longa extract is the main source of the antibacterial action.

Curcumin, the main bioactive component of turmeric, is responsible for the antimicrobial activity. It has been shown to interfere with vital cellular proteins, impair bacterial membrane integrity, and prevent nucleic acid synthesis. The formulation's therapeutic significance for topical administration in mild skin infections is supported by the concentration-dependent inhibitory pattern.

Overall, the findings show that the created herbal healing ointment has significant antibacterial activity and might be used in place of or in addition to traditional topical antimicrobial treatments.

7. ANTI-INFLAMMATORY ACTIVITY:

The protein denaturation method was used to assess the herbal healing ointment's anti-inflammatory properties. The standard reference medication was diclofenac sodium, and the negative control was the reagent control. Table 5 displays the findings.

Table 5. Percentage Inhibition of Protein Denaturation by the Formulated Ointment

S.NO	Concentration (mg/ml)	Formulated Ointment (% inhibition)	Diclofenac (% inhibition)	Control (%)
1.	50	45 ± 0.6	70 ± 0.4	5 ± 0.2
2.	75	59 ± 0.5	78 ± 0.3	6 ± 0.3
3.	100	72 ± 0.7	86 ± 0.5	7 ± 0.2

Values are expressed as Mean ± SD (n = 3).

Protein denaturation was inhibited by the prepared ointment in a concentration-dependent manner, reaching its maximal inhibition at 100 mg/ml (72 ± 0.7%). At 75 mg/ml (59 ± 0.5%), there was moderate inhibition, whereas at 50 mg/ml (45 ± 0.6%), there was significantly less activity.

The validity of the experimental approach was confirmed by the much stronger inhibition (70–86%) achieved by the conventional medication Diclofenac. The control group showed very little inhibition, suggesting that Curcuma longa extract is the main cause of the anti-inflammatory action.

Curcumin, which is known to reduce cyclooxygenase (COX) pathways to inhibit inflammatory mediators such prostaglandins and cytokines, may be responsible for the anti-inflammatory impact. When applied topically, the formulation's therapeutic ability to reduce inflammation is supported by the concentration-dependent response. Overall, the findings imply that the created herbal healing ointment has strong anti-inflammatory properties and could be useful for treating inflammatory skin disorders.

CONCLUSION

The current study effectively developed and assessed a Curcuma longa-containing herbal remedy. For topical application, the produced formulation demonstrated adequate spreadability and extrudability, high stability, and satisfactory physicochemical qualities. The ointment confirmed the therapeutic potential of turmeric-based formulations by exhibiting strong antibacterial and anti-inflammatory activity, especially against Staphylococcus aureus. The findings imply that the created herbal ointment is a reliable, safe, and affordable substitute for treating small cuts and skin infections. To confirm its effectiveness, more in vivo and clinical research is advised.

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