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Formulation and evaluation of a wound healing ointment containing ethanol extract of the rhizomes of mango ginger (*Curcuma amada*)

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Abstract
Wound healing is a vital biological process involving the restoration of damaged tissue through a series of cellular and molecular events. Herbal medicines have been traditionally used for wound care due to their safety, affordability, and therapeutic effectiveness. *Curcuma amada* Roxb. (Mango ginger), a member of the Zingiberaceae family, is known for its antimicrobial, anti-inflammatory, and antioxidant properties. This study was undertaken to formulate a wound healing ointment containing ethanol extract of *Curcuma amada* Roxb. Rhizomes and evaluate its physicochemical properties.
The rhizomes were collected, shade-dried, and extracted using the Soxhlet method with 70% ethanol. The prepared extract was incorporated into a topical ointment base and evaluated for parameters such as appearance, odor, pH, spreadability, viscosity, homogeneity, washability, and preliminary stability. The formulated ointment exhibited desirable characteristics, including smooth texture, uniform color, skin-compatible pH, and satisfactory stability. These findings support the traditional use of *Curcuma amada* Roxb. in wound management and suggest its potential for use in herbal topical formulations.

Keywords: *Curcuma amada* Roxb., wound healing, herbal ointment, Soxhlet extraction, topical formulation, physicochemical evaluation

Introduction
Wounds are physical injuries resulting in the disruption of the normal anatomical structure and function of the skin and underlying tissues. They can be caused by various external factors such as physical, chemical, thermal, microbial, or immunological agents. Wound healing is a highly organized biological process that involves complex interactions between different cell types, cytokines, and growth factors. The process progresses through a series of overlapping phases: hemostasis, inflammation, proliferation, and remodeling, ultimately leading to the restoration of tissue integrity and function [1, 2]. Delayed or improper healing can lead to complications such as infections, chronic wounds, and scar formation, increasing patient morbidity and healthcare costs. Traditionally, wound care involved the application of natural plant-based preparations due to their easy availability, minimal adverse effects, and broad pharmacological activities. Among these, several medicinal plants have been reported for their wound healing properties in various systems of medicine like Ayurveda, Siddha, and Unani [3]. *Curcuma amada* Roxb., commonly known as mango ginger, is a rhizomatous herbaceous plant belonging to the family Zingiberaceae. The plant is native to South and Southeast Asia and has been widely cultivated for its culinary and medicinal uses. Its rhizomes resemble ginger in appearance and emit a characteristic raw mango aroma, hence the name 'mango ginger' [4]. In traditional medicine, the rhizomes of *Curcuma amada* have been used for the management of inflammation, wounds, skin disorders, indigestion, and respiratory ailments [5]. Phytochemical investigations on *Curcuma amada* have revealed the presence of bioactive constituents such as curcuminoids, essential oils, terpenoids, phenolic compounds, and flavonoids. These phytoconstituents contribute to its anti-inflammatory, antimicrobial, antioxidant, and wound healing properties [6]. Several preclinical studies have demonstrated the wound healing potential of various Curcuma species, including Curcuma longa and Curcuma zedoaria, but limited research is available on the wound healing efficacy of *Curcuma amada* [7].
Herbal ointments are semi-solid topical preparations formulated to deliver active plant

directly to the wound site, promoting faster healing. The formulation of a stable and effective herbal ointment requires careful selection of suitable ointment bases and standardized extracts. The present study aims to formulate a wound healing ointment containing ethanol extract of the rhizomes of *Curcuma amada* and evaluate its physicochemical properties.

This research attempts to validate the traditional medicinal claims of mango ginger in wound management and provide scientific evidence for its potential use in modern herbal formulations. Given the increasing demand for plant-based therapeutics with minimal side effects, the study holds significant importance in the field of herbal drug development and wound care management.

Background of the study

One essential biological mechanism that repairs damaged tissues is wound healing. Chronic wounds and infections can result from delayed healing [1]. Because of their safety and therapeutic advantages, herbal medications are frequently utilized in traditional wound care [3]. Mango ginger, or *Curcuma amada* Roxb., is well-known for its antibacterial and anti-inflammatory qualities, but little is known about how well it can heal wounds [6, 8]. The goal of this study is to create and assess an herbal ointment that contains *Curcuma amada* ethanol extract.

Introduction to wound

A wound is characterized as a disturbance in the skin's and the underlying tissues' normal anatomical structure and function, typically brought on by physical, chemical, thermal, or microbiological harm. In order to avoid infection and consequences, wounds must be properly and promptly managed. A wound's etiology, depth, degree of contamination, and healing time can all be used to categorize it. Selecting appropriate treatment strategies for a successful recovery is made easier with an understanding of wound types [9, 1].

Classification of wounds

Open wounds

A rupture in the skin or mucous membrane that exposes interior tissues to the outside world is known as an open wound. Contamination and infection are more likely to occur in these wounds [10, 11, 12].

Open wound types include

- **Incision:** An incision is a neat, straight cut that is usually brought on by a sharp item, like a knife or medical tool.
- **Laceration:** A laceration is an uneven skin tear that frequently happens as a result of forceful trauma.
- **Abrasion:** An abrasion is a minor cut brought on by rubbing or scraping the skin against an uneven surface.
- **Puncture:** A puncture is a thin, deep wound caused by a sharp object, as a nail or needle.
- **Avulsion:** An avulsion is a serious incision where tissue is ripped or forced out of its natural position

Closed wounds

Closed wounds might entail damage to the underlying tissues but do not involve an obvious skin breach. These can induce internal bleeding and are typically brought on by forceful trauma [13, 14].

Closed wound types include

- **Contusion (Bruise):** A contusion (bruise) is a blunt force injury that damages blood vessels and causes blood to pool beneath the skin.
- **Hematoma:** Hematomas are localized collections of clotted blood caused by blood vessel rupture; they are frequently deeper and larger than contusions.
- **Crush injury:** When a body part is subjected to excessive force or pressure, it can cause crush injuries, which harm bones, muscles, and blood vessels without necessarily breaking the skin.

Challenges in wound healing treatment

Wound healing is hindered or made difficult by an array of clinical and environmental determinants. Major challenges include.

- **Risk of infection:** Exposed wounds are prone to microbial and fungal invasion, extending the inflammatory response and inhibiting the mechanisms of tissue repair [15].
- **Inadequate Blood Supply:** Impaired circulatory dynamics limit the delivery of oxygen and vital nutrients to the wound area, thus slowing granulation tissue formation and overall healing [1].
- **Chronic Inflammation:** Chronic inflammatory reactions can cause damage to the newly formed tissues, thus slowing the shift to the proliferative phase [1].
- **Excess Oxidative Stress:** The overproduction of reactive oxygen species (ROS) in the wound can cause harm to cellular architecture and impede collagen synthesis [16].
- **Systemic Health Conditions:** Pathologic states like diabetes, malnutrition, and peripheral vascular disease have negative impacts on immune functions and tissue regeneration abilities [1].
- **Antimicrobial Resistance:** The development of antibiotic-resistant organisms is a major challenge to infection control that may complicate wound care paradigms [15].
- **Elevated Treatment Expenses:** Advanced wound care treatments and advanced dressing products often involve high economic costs, thus limiting access for many patients, especially in resource-poor environments [17].
- **Scar Formation and Cosmetic Problems:** Poor healing of the wound can be followed by the formation of abnormal scarring such as keloids and hypertrophic scars that can negatively influence cosmetic as well as functional results [18].

Importance of herbal treatment in wound healing

Herbal drugs have been used for ages in the treatment of wounds due to their natural origin, safety, cost-effectiveness, and multifarious therapeutic benefits. Plant-based medicines possess antimicrobial, anti-inflammatory, and antioxidant properties that enhance the natural wound healing process [4, 5, 6].

The major strengths of herbal treatments in wound care are:

- **Antimicrobial Action:** A variety of medicinal plants possess intrinsic antibacterial and antifungal properties, helping to prevent or minimize wound infections.

- **Anti-inflammatory Activity:** Herbs reduce localized inflammation at the wound region, hence limiting tissue damage and promoting accelerated healing.
- **Antioxidant Activity:** Phytoconstituents like flavonoids and phenolics neutralize reactive oxygen species (ROS) and protect wound tissue from oxidative stress.
- **Collagen Synthesis Stimulation:** Herbal compounds stimulate fibroblast growth and increase collagen deposition, which are crucial in tissue regeneration and wound architecture.
- **Promotion of Epithelialization:** Herbal preparations aid in the formation of new epithelial layers, thus hastening wound closure.
- **Reduced Chances of Side Effects:** Compared to artificial drugs, herbal drugs are mostly well tolerated and cause fewer side effects.
- **Cost-Effectiveness and Accessibility:** Herbal remedies are cost-effective and easily available, making them highly beneficial for use among rural and economically backward populations.
- **Traditional and Cultural Acceptance:** Herbal medication has vast acceptance with patients and cultural validation across many parts of the world, thus boosting patient compliance.

Introduction to mango ginger (*Curcuma amada)*

Mango ginger (*Curcuma amada* Roxb.) is a perennial, rhizomatous herb belonging to the Zingiberaceae family. In spite of its morphological resemblance to the common ginger (Zingiber officinale), its rhizome possesses a special aroma resembling that of raw mango, thereby earning it the name 'mango ginger.' The plant has a large geographical range in India, Southeast Asia, and other parts of the tropics, where it is grown for food as well as medicinal purposes [4].

Botanical Description

- **Botanical Designation:** *Curcuma amada* Roxb.
- **Taxonomic Family:** Zingiberaceae.
- **Common Nomenclature:** Mango Ginger (English), Amba Haldi (Hindi).
- **Plant Classification:** Perennial, herbaceous, and rhizomatous species.
- **Rhizome Characteristics:** Succulent, robust, and fragrant; bears resemblance to conventional ginger while exuding a fragrance reminiscent of raw mango.
- **Foliar Structure:** Simple, broad, lanceolate, and green; organized in a two-row arrangement; petiole elongated and sheathing at the base.
- **Inflorescence Structure:** Spike, emerging directly from the rhizome; bracts exhibit greenish or pinkish hues.
- **Floral Characteristics:** Small, pale yellow flowers adorned with reddish tips.
- **Propagation Method:** Via rhizomes (vegetative propagation).
- **Blooming Period:** Generally occurs during the monsoon season (July-August) in India
- **Utilized Part:** Rhizome [4].

Habitat and Distribution

Habitat

Prefers warm, subtropical, and tropical climatic regions. Shows a tendency for sandy loam, well-drained, and organically rich soil mixtures. Commonly grown in home gardens, agricultural fields, and herbal cultivation farms

Geographical Distribution

- **India:** Widespread cultivation in the states of Maharashtra, Karnataka, Kerala, Tamil Nadu, Andhra Pradesh, Odisha, Uttarakhand, and the Indian Northeast.
- **Southeast Asia:** Found in Myanmar, Thailand, Malaysia, and Indonesia.

Also, found in Sri Lanka and other parts of tropical South Asia [5].

Traditional use

The traditional uses of mango ginger are [4, 5]

- Used as a carminative drug to relieve gastrointestinal pain, distension, and excessive gas formation as part of conventional medicine.
- Applied in topical form on cuts, lacerations, and skin infections to check inflammation and aid the healing process.
- Consumed as a digestive stimulant in the form of preserved vegetables, chili condiments, and other food preparations.
- Traditionally used in Ayurvedic and traditional medicinal uses to treat respiratory disorders like cough and rhinorrhea.
- Used as a hepatoprotective agent to promote hepatic function in traditional medical practices.
- Used to treat skin conditions, insect bites, and itching due to its anti-inflammatory and antimicrobial activities.
- Used externally for relief from pain and discomfort in sprains, edema, and gout.
- Used traditionally as a natural purgative for blood purification and detoxication.
- Used as a thermoregulatory drug in warmer times of the year in many parts of India for its calming nature.
- Recommended for the relief of nausea and gestational discomfort in the context of traditional medicine.

Pharmacological Activity

The pharmacological activities are [5, 6, 8]

Anti-inflammatory Activity

The rhizomes of Mango ginger have traditionally been used as poultice and local ointment for the treatment of inflamed wounds, sprains, and arthralgia. Its anti-inflammatory activity is largely attributed to its essential oil components, especially ar-turmerone and camphor, in addition to several phenolic compounds. Preclinical studies have supported significant inhibition of inflammatory mediators like prostaglandins and cytokines in experimental models, thus validating its use in the treatment of inflammation-related disorders.

Antimicrobial Activity

Curcuma amada extracts display wide-spectrum action against both fungal and bacterial pathogens. The growth inhibition of dermatologically important bacteria such as Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli can be related to the essential oils and

phenolic compounds present. This antimicrobial property makes it beneficial for the cure of cutaneous infections, ulcers, and wounds and hence plays a preventive role against secondary infections.

Antioxidant Activity

Curcuma amada rhizomes contain flavonoids, curcuminoids, and phenolic acids with very good free radical scavenging activity. These antioxidants protect tissue against oxidative stress-induced cellular damage, which is the major cause for extended wound healing and chronic wounds. In addition, antioxidants enhance collagen synthesis and angiogenesis in the course of tissue repair.

Wound Healing Activity

The local application of *Curcuma amada* extract has been demonstrated to hasten wound contraction, augment fibroblast proliferation, and enhance collagen deposition in model wounds. Its antioxidant, antimicrobial, and anti-inflammatory activities synergistically promote the wound healing process by reducing the microbial load, modulating inflammation, and enhancing epithelialization.

Hepatoprotective Activity

In traditional medicine, *Curcuma amada* is utilized to stimulate liver functions and treat liver pathologies. The phenolic constituents present in this species possess strong antioxidant and free radical scavenging activity, which are responsible for the protection of hepatic tissues against drug-induced hepatotoxicity and oxidative stress.

Carminative and Digestive Activity

Mango ginger has traditionally been used as a household treatment for gastrointestinal upsets, such as but not restricted to indigestion, flatulence, colic, and anorexia. Its carminative action aids in the relief of intestinal gas and promotion of digestive secretions. Additionally, the essential oils present in the rhizome, like camphor and curcumene, have been found to exhibit gastroprotective properties.

Antinausea and Antiemetic Activity

Traditionally, *Curcuma amada* has been consumed in cases of nausea, vomiting, and morning sickness during pregnancy. The bioactive compounds present in the rhizome exert a soothing effect on the gastrointestinal tract and help modulate gastric motility, hence reducing feelings of nausea.

Analgesic (Pain-Relieving) Activity

Topical application of *Curcuma amada* paste or ointment has been traditionally used for the relief of local pain in conditions like arthralgia, sprains, and muscle pain. The moderately analgesic activity of the compound is due to the presence of essential oils and curcuminoids which act on pain modulation pathways.

Antiallergic and Antipruritic Activity

Mango ginger is traditionally used topically for the relief of insect bites, itchiness, and allergic skin diseases. Its antihistaminic and anti-inflammatory properties extensively reduce erythema, edema, and inflammation associated with allergenic reactions.

Anticancer Activity

Primary *et al* studies have shown the cytotoxic activity of *Curcuma amada* extracts against certain human neoplastic cell lines. This is attributed to its curcuminoids and terpenoids, which have inhibitory activity against the growth of cells and enhance the process of apoptosis.

Summary Table

The following summary table is [5, 6, 8]

Pharmacological Activity	Mechanism
Anti-inflammatory, Antioxidant, Wound healing	Inhibit cytokines, neutralize free radicals, enhance collagen formation
Antimicrobial, Analgesic, Carminativ	Disrupt microbial membranes, modulate pain, stimulate bile secretion
Antioxidant, Anti-inflammatory, Antihistaminic	Scavenge ROS, stabilize mast cells, reduce inflammation
Antioxidant, Antimicrobial	Neutralize free radicals, damage microbial membranes
Anti-inflammatory, Antimicrobial, Analgesic	Suppress inflammatory mediators, impair pathogen growth
Astringent, Wound healing	Form protective barriers, contract tissues
Anti-inflammatory, Expectorant	Modulate inflammatory response, promote mucus expulsion

Phytoconstituents of the mango ginger (*Curcuma amada)*

Curcuminoids (Curcumin, Demethoxycurcumin, Bisdemethoxycurcumin)

- **Activities:** Shows anti-inflammatory activity, has antioxidant activity, supports wound healing, and shows anticancer activity.
- **Role:** Supresses the action of inflammatory mediators, quenches reactive oxygen species, encourages fibroblast proliferation, and enhances collagen synthesis.

Essential Oils (ar-Turmerone, β-Myrcene, Ocimene, Camphor, Curcumene)

- **Activities:** Exhibits antimicrobial activity, offers analgesic pain relief, functions as a carminative agent, and features hepatoprotective activity.
- **Role:** Disrupts microbial membrane integrity, modulates neurotransmitter mechanism in pain reduction, aids in digestion, and protects hepatic cells.

Flavonoids (Kaempferol, Quercetin, Rutin)

- **Activities:** Acts as an antioxidant, has anti-inflammatory activity, stimulates wound healing, and has antihistaminic activity.
- **Role:** Scavenges free radicals, stabilizes mast cells, reduces inflammatory responses, and supports the regeneration of epithelial tissues.

Phenolic Compounds (Ferulic acid, Caffeic acid)

- **Activities:** Antioxidant, Antimicrobial, Hepatoprotective
- **Role:** Reduces oxidative stress, inhibits microbial growth, and protects hepatic tissues.

Terpenoids (Monoterpenes, Sesquiterpenes)

- **Activities:** Anti-inflammatory, Antimicrobial, Analgesic, Anticancer
- **Role:** Suppresses inflammatory signaling pathways,

weakens microbial cellular membranes, relieves pain, and induces apoptosis in neoplastic cells.

Tannins
- **Activities:** Astringent, Antimicrobial, Wound healing
- **Role:** Forms a protective shield on lesions, causes tissue contraction, and inhibits microbial growth.

Saponins
- **Activities:** Anti-inflammatory, Expectorant, Antimicrobial
- **Role:** Modulates inflammatory mediators, promotes mucus clearance from the respiratory tract, and interferes with bacterial cellular membranes.

Glycosides
- **Activities:** Anti-inflammatory and antimicrobial properties
- **Role:** help to fight infections and reduce inflammation.

Phytoconstituent	Pharmacological activity
Curcuminoids (Curcumin, Demethoxycurcumin, Bisdemethoxycurcumin)	Anti-inflammatory, Antioxidant, Wound healing, Anticancer
Essential Oils (ar-Turmerone, β-Myrcene, Ocimene, Camphor, Curcumene)	Antimicrobial, Analgesic, Carminative, Hepatoprotective
Flavonoids (Kaempferol, Quercetin, Rutin)	Antioxidant, Anti-inflammatory, Antihistaminic, Wound healing
Phenolic Compounds (Ferulic acid, Caffeic acid)	Antioxidant, Antimicrobial, Hepatoprotective
Terpenoids (Monoterpenes, Sesquiterpenes)	Anti-inflammatory, Antimicrobial, Analgesic, Anticancer
Tannins	Astringent, Antimicrobial, Wound healing
Saponins	Anti-inflammatory, Expectorant, Antimicrobial
Glycosides	Anti-inflammatory, Antimicrobial

Rationale of the study

Wound healing is a complex, dynamic, and vital biological process that restores the function and structure of injured tissues through a series of overlapping phases that involve hemostasis, inflammation, proliferation, and remodeling. Especially in those with underlying systemic diseases such as diabetes, malnutrition, and vascular diseases, impaired or delayed wound healing remains a significant public health issue because it often leads to chronic wounds, secondary infection, and elevated morbidity [1]. Several limitations continue to persist despite the progress in modern wound care treatments, including treatment costs that are excessively high, drug-induced side effects, and the growing problem of antibiotic resistance in wound infections [15].

In this respect, much interest has been generated in exploring natural and plant-based remedies in wound healing treatment. Many bioactive phytoconstituents present in medicinal plants exhibit synergistic pharmacological actions like analgesic, antibacterial, anti-inflammatory, antioxidant, and healing properties. In most poor countries, plant medicines are generally available, harmless, culturally acceptable, and affordable [5]. Amongst these, the medicinal herb *Curcuma amada* Roxb., commonly referred to as mango ginger, has been used in Ayurvedic, Siddha, and traditional medical practices for a long time. Very little scientific information on the topical application of *Curcuma amada* and its wound-healing property is available even though it belongs to the same genus as Curcuma longa, whose effectiveness in healing wounds is well documented. Curcuminoids, flavonoids, phenolic compounds, essential oils, and terpenoids-phytochemicals possessing antibacterial, anti-inflammatory, antioxidant, and tissue-repairing activities-are present in large numbers in *Curcuma amada* rhizomes [6, 8].

As per several preclinical studies and ethnobotanical surveys, *Curcuma amada* possesses great anti-inflammatory, antibacterial, hepatoprotective, and carminative activities. To reduce swelling and promote healing, it has been traditionally applied externally as a paste to wounds, insect bites, and skin disorders [5, 8]. Its phenolic and flavonoid compounds' antioxidant activity combats oxidative stress at the wound site, while its essential oils aid in antibacterial activity and inhibit secondary infection of the wound [6]. This research was undertaken to develop and evaluate a herbal wound healing ointment comprising ethanol extract of *Curcuma amada* Roxb. rhizomes, considering its conventional health claims, phytoconstituent profile, and increasing need for safe, effective, and natural wound care products. For the purpose of proving its traditional use and exploring its scope in modern phytopharmaceutical applications, the preparation shall be tested for its physicochemical properties, stability, and efficacy as a local wound healing agent.

Aim and Objective

Aim

To formulate and evaluate a wound healing ointment containing ethanol extract of the rhizomes of *Curcuma amada* Roxb. and assess its physicochemical properties and stability for potential use in herbal wound care formulations.

Objective
- To collectthe rhizomes of *Curcuma amada* Roxb.
- To prepare the ethanol extract of *Curcuma amada* rhizomes using Soxhlet extraction technique.
- To prepare an herbal wound healing ointment.

To evaluate the prepared ointments for various physicochemical parameters including appearance, pH, spreadability, extrudability, homogeneity, viscosity, washability, loss on drying, and stability.

Research Hypothesis
- The formulated *Curcuma amada* Roxb. herbal ointment will possess good physical stability and acceptable pH suitable for topical application.
- The herbal ointment will be safe for skin use without causing irritation or adverse effects.
- The ethanol extract-based ointment will exhibit favorable physicochemical properties like spreadability, homogeneity, extrudability, and washability.

- The ointment formulation will remain stable under both room temperature and accelerated storage conditions over a study period.
- The *Curcuma amada* Roxb. extract-based ointment will support wound healing through its antimicrobial, anti-inflammatory, and antioxidant phytoconstituents, helping to promote tissue repair and prevent wound infections.

Scope of the Study

This research focuses only on

- Extraction of active phytoconstituents from the rhizomes of *Curcuma amada* Roxb. using ethanol as a solvent.
- Formulation and standardization of a topical herbal ointment incorporating the ethanol extract of *Curcuma amada* Roxb.
- Evaluation of the formulated ointments for their physical, physicochemical, and stability parameters, including appearance, pH, spreadability, homogeneity, extrudability, washability, and viscosity.
- Assessment of the stability of the formulations under room temperature and accelerated storage conditions.

Materials and Methods

Materials

Plant Materials

Rhizomes of Mango Ginger (*Curcuma amada)* were collected and used for the preparation of the herbal extract.

Chemicals and Reagents

Petroleum Jelly, Soft Paraffin, Beeswax, Liquid Paraffin, Cetostearyl Alcohol, Methyl Paraben (Preservative), 70% Ethanol (For extraction), Distilled Water.

Table 1: Formulation composition table

Ingredients	Quantity(gm/100 gm)	Functions
Curcuma amada Extract (Ethanolic)	5	Active herbal agent
Petroleum Jelly	60	Base
Soft Paraffin	15	Texture and body
Beeswax	10	Stiffening agent
Liquid Paraffin	5	Emollient
Cetostearyl Alcohol	5	Emulsifier and emollient
Methyl Paraben	0.2	Preservative

Fig 1: Melting of petroleum jelly

Fig 2: Melting of beeswax

Fig 3: Concentrated extract

Methods

Collection and Drying

Fresh rhizomes of *Curcuma amada* (Mango Ginger) were collected manually from a local market. The rhizomes were thoroughly washed with tap water followed by distilled water to eliminate soil, debris, and other contaminants. The cleaned rhizomes were sliced into small pieces and shade-dried at room temperature for 7-10 days to preserve thermolabile (heat-sensitive) constituents. Once completely dried, the rhizomes were ground into a coarse powder using a mechanical grinder [19].

Fig 4: Fresh rhizomes of Mango Ginger

Fig 5: Fresh Mango Ginger powder

Preparation of Plant Extract
Method: Soxhlet Extraction Method

Procedure

- A total of 120 grams of dried and coarsely powdered *Curcuma amada* rhizome was divided equally and packed into three Soxhlet apparatus (40 g each).
- Hydroalcoholic solvent (ethanol: water in the ratio 7:3) was used as the extraction medium.
- Extraction was performed in each Soxhlet assembly separately for 8-10 hours until the solvent in the siphon tube turned colorless, indicating exhaustive extraction.
- The collected extract was filtered and then concentrated using a heating mantle at 40-50 °C to evaporate the solvent.
- The resulting semi-solid or viscous extract was stored in a clean, airtight container and kept at 4 °C until used in ointment formulation.

Formulation of the Ointment
The ointment formulation was developed using the following method:

Ointment Base Preparation
Petroleum jelly, soft paraffin, beeswax, liquid paraffin, and cetostearyl alcohol were accurately weighed and taken in a clean beaker. These ingredients were melted together using the fusion method by heating on a water bath at approximately 70 °C with continuous stirring until a homogeneous molten base was formed.

Incorporation of Preservative
Methyl paraben (used as preservative) was dissolved separately in a small quantity of warm liquid paraffin and added to the molten base with continuous stirring to ensure uniform distribution.

Addition of Plant Extract
After the base was completely melted and uniform, the temperature was allowed to cool slightly to 40-45 °C. At this point, 5 g of the ethanol extract of *Curcuma amada* was gradually added to the base with constant stirring using a glass rod or homogenizer.
Stirring was continued until a uniform and smooth ointment was formed.
The prepared herbal ointment was then transferred into clean, sterilized wide-mouth ointment containers [20].

Fig 6: Soxhlet extraction of Mango Ginger powder

Fig 7: Concentrating the extract

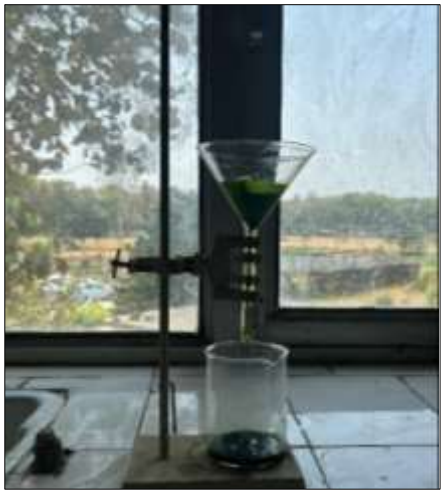

Fig 8: Filtration of the extract

Fig 9: Final product

Evaluation of the Ointment

Physical Appearance and Color

- **Principle:** The appearance reflects the physical integrity and aesthetic value of the formulation [21].
- **Method:** A small amount of ointment was taken and observed visually against a white background in natural light.
- **Ideal Result:** Uniform, glossy, greenish-yellow color without phase separation or particulate matter.

Odor Evaluation

Principle: The odor provides an indication of formulation acceptability and stability [22].
Method: The odor was assessed immediately after container opening and compared to a standard herbal odor profile.
Ideal Result: Mild, pleasant herbal aroma without rancid or offensive notes.

Texture Evaluation

- **Principle:** Texture influences patient compliance and indicates emulsification efficiency [23].
- **Method:** A small quantity was rubbed between fingers, and feel was noted.
- **Ideal Result:** Smooth, uniform, non-greasy, and non-gritty texture.

Homogeneity Test

- **Principle:** Ensures uniform distribution of active constituents within the base [24].
- **Method:** A thin layer was spread on a glass slide and observed for presence of aggregates or coarse particles.
- **Ideal Result:** Uniform, smooth, and homogenous with no visible lumps or phase separation.

Spreadability Test

- **Principle:** Determines ease of application over the skin, affecting therapeutic efficiency [25].
- **Method:** 1 g of ointment placed between two glass slides, a 500 g weight applied, and time noted for upper slide to move a specified distance.
- **Ideal Result:** Good spreadability without being too stiff or too runny.

pH Determination

- **Principle:** Skin-compatible pH prevents irritation and enhances product acceptability [25].
- **Method:** 1% w/w ointment dispersion in distilled water measured using a calibrated digital pH meter.
- **Ideal Result:** Between 5.5 to 6.5.

Washability Test

Principle: Indicates ease of removal from skin after application, crucial for topical preparations [21].
Method: The ointment was applied on skin, allowed to stand for 10 minutes, then washed with lukewarm water.
Ideal Result: Easily washable without soap.

Viscosity Measurement

- **Principle:** Viscosity determines spreadability, drug release, and storage stability [27].
- **Method:** Measured with a Brookfield Viscometer at 25 °C, using spindle no. 64 at 100 rpm.
- **Ideal Result:** 10,000-50,000 cP.

Loss on Drying

- **Principle:** Evaluates moisture and volatile content which can promote microbial growth or instability [26].
- **Method:** Weighed quantity of ointment heated at 105°C, and weight loss recorded.
- **Ideal Result:** Less than 5%.

Melting Point of Base

- **Principle:** Confirms thermal behavior and consistency of the ointment base [23].
- **Method:** Melting point determined using capillary method in a water bath.
- **Ideal Result:** Consistent with base-specific range (commonly 45-65 °C).

Grittiness Test

- **Principle:** Detects presence of coarse particles which can irritate skin and indicate poor formulation [24].
- **Method:** A pinch of ointment was rubbed between fingers, and any gritty sensation was noted.
- **Ideal Result:** No grittiness; smooth, fine texture.

Results and conclusion

Results

The wound healing ointment containing ethanol extract of *Curcuma amada* Roxb. was successfully formulated using standard pharmaceutical procedures. The prepared formulation was evaluated for various physicochemical parameters to assess its suitability as a topical application.

The physical examination revealed that the ointment exhibited a smooth, homogeneous texture without any phase separation or grittiness. It showed a characteristic mild herbal odor, with no offensive or rancid smell. The color of the ointment remained stable, exhibiting a uniform greenish-yellow hue, which did not change throughout the observation period.

Table 2: Physical Evaluation Parameters of Formulated Ointment

Parameter	Observation
Color	Uniform greenish-yellow
Odor	Mild, pleasant herbal smell
Texture	Smooth, homogeneous, non-gritty
pH	5.7
Spreadability	Good, uniform, and acceptable
Washability	Easily washable with water
Viscosity	Within acceptable semi-solid range
Homogeneity	No phase separation, uniform distribution
Grittiness	Absent
Stability (4 weeks)	No color change, no liquefaction, no odor change, no microbial growth

The pH of the formulation was within the acceptable range for topical applications (5.5-6.5), indicating good skin compatibility. The spreadability test confirmed satisfactory ease of application, with neither excessive stiffness nor runniness. The ointment demonstrated good washability, being easily removed with lukewarm water without leaving a greasy residue.

Viscosity measurements showed that the formulation maintained a semi-solid consistency suitable for topical application, with values within the recommended range. Preliminary stability observations conducted over four weeks at different storage conditions (room temperature, refrigeration, and elevated temperature) showed no signs of microbial contamination, color change, phase separation, or odor alteration.

The formulated ointment thus exhibited promising physical and organoleptic characteristics supportive of its potential application in wound healing.

Conclusion

The present study was aimed at the formulation and evaluation of a wound healing ointment containing ethanol extract of *Curcuma amada* Roxb. The herbal extract was successfully incorporated into a suitable ointment base comprising ingredients such as white soft paraffin, cetostearyl alcohol, wool fat, and liquid paraffin, resulting in a stable and acceptable topical formulation.

Evaluation studies revealed that the prepared herbal ointment possessed desirable physicochemical characteristics, including appropriate pH, good spreadability, smooth texture, homogeneity, easy washability, and stability under different storage conditions. These findings suggest that the formulated ointment is safe and suitable for topical application.

The results indicate that incorporating *Curcuma amada* Roxb. extract into a semi-solid base may contribute to wound healing activity while offering the added advantages of herbal formulations, such as minimized side effects and enhanced patient acceptability. However, further in-depth pharmacological studies and clinical trials are necessary to confirm the therapeutic efficacy and establish the safety profile of the formulation on a larger scale.

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