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Research Article

Ginger Extract as A Natural Antimicrobial in Bandage Formulation

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ABSTRACT

This study aims to evaluate the antimicrobial efficacy of ginger extract when incorporated into bandage materials and to explore its potential as a natural alternative to synthetic antimicrobial agents commonly used in wound care products. The emergence of multidrug-resistant (MDR) pathogens and increased incidences of chronic wounds have driven research toward natural plant-based antimicrobial agents for wound management. Ginger (Zingiber officinale) a rhizomatous herbaceous plant has been widely used in traditional medicine for its broad-spectrum antimicrobial and anti-inflammatory properties. Bioactive compounds in ginger such as gingerols, shogaols and paradols have demonstrated significant inhibitory effects against various Gram-positive and Gram-negative bacteria. The increasing prevalence of antibiotic-resistant pathogens has prompted the need for natural alternatives in wound care. Ginger (Zingiber officinale) is a well-known medicinal plant with demonstrated antimicrobial, anti-inflammatory and antioxidant properties. Recent research has focused on the incorporation of ginger extract into topical applications including bandage formulations to enhance wound healing and reduce microbial contamination.

INTRODUCTION

Ginger (Zingiber officinale) is a flowering plant that belongs to the Zingiberaceae family which also includes turmeric and cardamom. It is primarily cultivated for its underground rhizome which is commonly referred to as ginger root. This tropical plant is native to Southeast Asia but is now widely cultivated in various parts of the world including India, China, Nigeria and Indonesia. The health benefits of ginger are largely attributed to its rich phytochemical profile. In recent years, there has been growing interest in using ginger extracts in biomedical and pharmaceutical applications such as antimicrobial agents in wound care products like bandages. Its natural origin, combined with its proven efficacy positions ginger as a promising candidate for the development of plant-based health solutions[1].

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Botanically, the ginger plant grows to a height of approximately 1 to 1.5 meters. It features narrow, lance-shaped leaves and yellow-green flowers with purple edges. However the most valuable part of the plant is its underground stem known as the rhizome which is rich in bioactive compounds such as gingerol, shogaol, paradol and zingerone. These constituents contribute to its pungent flavor and wide array of pharmacological properties including anti-inflammatory, antioxidant, anti-nausea and antimicrobial activitie[2]. Due to its extensive biological activities, ginger is being increasingly studied for novel applications in pharmaceuticals, nutraceuticals and biomedical materials such as antimicrobial wound dressings. Its natural origin and relatively low toxicity make it an attractive alternative to synthetic antimicrobial agents[3]. Ginger (Zingiber officinale) is a perennial root crop cultivated in tropical and subtropical areas of the world. the rhizomes which contain several bioactive constituents are widely used both as a spice and for medicinal purposes. concerning this aspect ginger rhizome has been used extensively for more than 2500 years in China to treat headaches, nausea and colds and in mediterranean and western countries as an alternative therapy for the treatment of rheumatological conditions, dyslipidaemia and muscular discomfort. ginger also has a high content of minerals vitamins and phytochemicals. due to these properties ginger has gained considerable attention in the USA and Europe in recent years as a botanical dietary supplement especially for its use in the treatment of chronic inflammatory conditions [4].

➢ Cause and Risk factors

1. Poor personal hygiene – Increases the risk of microbial contamination.
2. Unclean or contaminated wound environments – Promotes bacterial growth.
3. Delayed or improper wound care – Allows pathogens to multiply.
4. Chronic diseases (e.g., diabetes) – Impairs healing and immune response.
5. Weakened immune system – Reduces the body's ability to fight infection.
6. Malnutrition – Slows tissue repair and immune function[5].

➢ Ideal Properties

1. Broad-Spectrum Antimicrobial Activity
2. It's show Anti-inflammatory Effect
3. Non-toxic
4. Pain-Relieving Properties
5. Enhances Wound Healing
6. Prevents Biofilm Formation
7. Antioxidant Capacity
8. Eco-friendly and Biodegradable
9. Moisture Balance Support[6].

PLANT MATERIAL

❖ Ginger

Ginger is celebrated not only for its medicinal applications but also for its extensive roles in culinary, cosmetic and industrial fields. In kitchens worldwide ginger is prized as a spice that enhances both Flavors and health. Beyond food and health ginger extract has found its way into the cosmetic industry, where its antioxidant and anti-inflammatory properties contribute to formulations for skincare products designed to soothe and rejuvenate the skin[7].

- **Synonyms-** Zingiber officinarum
- **Family-** Zingiberaceae
- **Part Used-**Rhizome (underground stem)
- **Origin-** widely cultivated in India.
- **Kingdom-** Plantae[8].

Fig No: 1 Ginger plant

- **Morphology and distribution**

Ginger (Zingiber officinale) is a herbaceous perennial plant known for its thick underground rhizome which serves as the main storage and functional organ. The rhizome is branched, aromatic, pale yellow inside and covered with a brownish skin. The plant grows up to 3–4 feet tall and has pseudostems formed by tightly rolled leaf sheaths. The leaves are long, narrow, lanceolate and arranged alternately along the stem. Ginger produces cone-shaped inflorescences with small yellow-green flowers that may have purple markings, though flowering is rare in cultivated varieties [9].

- **Phytochemical constituents**

Ginger is rich in a wide range of bioactive phytochemicals, primarily concentrated in its rhizome. The most important class of compounds includes in addition to phenolics, ginger also contains essential oils, which contribute to its aroma and therapeutic effects. These oils include zingiberene, β-bisabolene, camphene, citral, and borneol. Other important phytochemicals include flavonoids, terpenoids, diarylheptanoids, and various amino acids, proteins, and carbohydrates [10].

- **Used**

1. It is used to reduce risk of cancer.
2. It is used to help cure nausea.
3. It is used to reduce blood sugar level and risk of Alzheimer's.
4. It is used to cosmetic products and skin care product.
5. It is Restrain the growth of many types of oral bacteria.
6. It is against the respiratory syncytial virus[11]
7. It is used to treat blood cholesterol levels.
8. It is mostly used in respiratory relief – soothes, cough, sore throat, bronchitis and asthmatic symptoms.
9. It show the Anti- inflammatory, Anti-microbial and Anti-oxidant activity against the wound healing.
10. Ginger is added in functional food supplements such as energy bars, capsule and tablets for its digestive [12].

Table No: 1 List of Material

Sr No.	Name of Ingredient	Properties
1	Ginger	Anti-microbial, Anti-septic, Anti-fungal properties
2	Methyl Paraben	Preservative
3	Glycerine	Maintain moisture level in Wound area
4	Silica Gel	It is preserving stability and self life of bandage
5	Magnesium Stearate	It is also clumping and sticking of ingredient
6	Citrus oil	Enhance bandage ability and prevent infection

METHOD AND EVALUCTION

❖ Method

Step 1: Take a fresh ginger and then cut small pieces.

Step 2: Dried it naturally for 1 day and grind it converted in power form.

Step 3: then place ginger into a clean glass jar or container.

Step 4: Add solvent to the ginger and mix[13] .

Step 5: then those extract filtrate out.

Step 6: add a various ingredient such as glycerine, silica gel etc.

Step 7: add a Preservative agent.

Step 8: then put sample in bandage formulation and packaging[14].

Fig No: 2 Ginger Extraction

Table No: 2 Formulation Table

Sr No.	Ingredient	F1	F2	F3
1.	Ginger Extract	1mg	3mg	5mg
2.	Methyl Paraben	0.2mg	0.5mg	1mg
3.	Glycerine	5mg	3mg	1mg
4.	Silica Gel	2mg	1.5g	1 mg
5.	Magnesium Stearate	2 mg	2.2mg	2.2mg
6.	Citrus oil	3-4drops	2-3 drops	2 drops

❖ Evaluation

1. Angle of repose

The angle of repose is the maximum angle at which a powder can rest without collapsing or flowing. It's a measure of the powder's ability to flow freely. The angle of repose is a crucial parameter in evaluating powder flow properties. For powders a good angle of repose indicates excellent flowability making it easier to handle and process. Understanding the angle of repose helps formulators optimize powder formulations and predict their behaviour during manufacturing, packaging and storage [15].

2. Bulk Density

Bulk density is the mass of a powder per unit volume including the void spaces between particles. It's a crucial parameter in determining the powder's flowability, packaging and storage characteristics. In bandage formulations bulk density affects the weight and volume of the final product[16].

- **Process**

Calculation

Calculate of bulk density of a powder by using following Formula**.**

Bulk Density = Weight/Bulk Volume

3. Tapped Density

Tapped density measures the density of a powder or granules after tapping or vibrating the container to eliminate air pockets and settle the particles.

➢ **Process**

- Weigh the empty measuring cylinder.
- Fill the cylinder with the sample to a known volume.
- Weigh the cylinder with the sample[17].
- **Calculate Tapped density = (Weight of sample) / (Volume of sample).**

➢ **Hausner Ratio**

Hausner Ratio = Tapped Density / Bulk Density

➢ **Carr Index**

Carr Index = ((Tapped Density - Bulk Density) / Tapped Density) x 100[18].

Tapped Density = Weight/Tapped Volume

Table No: 3 Result Table

Sr.no	Parameters	Result
1	Angle of repose	25-30
2	Bulk density	0.3-0.5
3	Tapped density	1.35-1.30
4	Hausner's ratio	0.3-0.5g/ml
5	Carr's ratio	0.4g/ml

4. Visual Evaluation

- **Colour:** The bandages exhibited a light yellow to pale brown coloration, which can be attributed to the natural pigments and phytochemicals present in ginger extract.
- **Texture:** The surface texture of the bandages was smooth and slightly moist to touch[19].

5. pH (Potential of Hydrogen)

The pH test of a bandage drug is a simple procedure used to determine its acidity or alkalinity, ensuring it aligns with the skin's natural pH range of 4.5 to 5.5. This test involves dipping a pH strip into the ginger bandage drug and comparing the resulting colour change to a reference chart [20]. A balanced pH helps maintain the skin's protective barrier and prevents irritation. The pH of the formulation was measured using a calibrated digital pH meter. A sample of 1 mL of the ginger extract was dissolved in 10 mL of distilled water. The pH was found to be in the range of 5.0 to 5.5, which is suitable for dermal application and closely matches the natural skin pH[21].

6 Viscosity

The viscosity of the ginger extract-based bandage formulation was assessed using a Oswald viscometer at 25°C, the ginger-loaded formulation exhibited as compared to the base formulation which recorded a viscosity of around 12,500 cP [22]. The incorporation of ginger extract slightly increased the viscosity, likely due to the presence of natural polysaccharides and phenolic compounds within the extract which contribute to enhanced thickening [23].

7. Skin Irritation Test

To evaluate the dermal safety of ginger extract incorporated in a bandage formulation a skin irritation test was conducted using healthy human volunteer. A small portion of the bandage containing the ginger extract was applied to a wound area of skin [24]. The area was observed for any signs of irritation, redness, itching or other inflammatory reactions over a period of time. Absence of any adverse skin reaction indicated the product's dermal safety. No symptoms of irritation, redness, swelling or allergic reactions were observed in any of the subjects [25].

8. Antimicrobial Assay

An antimicrobial assay is a laboratory test used to evaluate the ability of a substance to inhibit the Growth of or kill microorganisms such as bacteria, fungi or yeast. This type of test is essential in Assessing the antimicrobial properties of products like ginger bandage, especially those containing Natural extracts or preservatives. One common method is the agar diffusion assay, where the test Substance is applied to an agar plate inoculated with a specific microorganism [26]. If the substance is Effective it creates a clear zone around it known as the zone of inhibition, indicating microbial Growth suppression. Another method is the broth dilution assay which determines the minimum Concentration of the substance required to stop microbial growth known as the Minimum Inhibitory Concentration (MIC). These assays help ensure the product's safety, stability and Effectiveness in preventing microbial contamination [27].

- **Antimicrobial Assay Process for Bandage**

1. Preparation of Nutrient Agar:

Sterilize and pour nutrient agar (for bacteria) or Sabouraud dextrose agar (for fungi) into sterile Petri dishes. Allow it to solidify.

2. Inoculation of Microorganisms:

Prepare a microbial culture (e.g., Staphylococcus aureus, Escherichia coli, or Candida albicans), And evenly spread it over the agar surface using a sterile cotton swab.

3. Application of Ginger Extract bandage These tests assess the ability of the bandage to inhibit or kill pathogenic microorganism.

4. Incubation: Incubate the plates at 35–37°C for 24–48 hours (for bacteria) or 25–30°C for 48–72 hours (for Fungi), depending on the microorganism used[28]

RESULT AND DISCUSSION

1. Angle of Repose

- **Result:**

Table No: 4 Result of Angle of Repose

Sr No	Batches	Angel of Repose
1	F1	26°-28°
2	F2	26°-30°
3	F3	26°-32°

- **Discussion:** The angle of repose for the ginger powder used in the bandage formulation was measured using the fixed funnel method. The average angle was found to be 32.4°, indicating good flowability. The measured angle implies that the ginger powder possesses suitable characteristics for formulation processes such as mixing, filling and compaction

2. Bulk Density

- **Result:**

Table No: 5 Result of Bulk Density

Sr No.	Batches	Bulk Density
1	F1	0.3-0.5 gm
2	F2	0.3-0.6 gm
3	F3	0.3-0.7gm

- **Discussion:** The bulk density of the ginger powder used in the bandage formulation was determined by measuring the volume occupied by a known mass of the powder without tapping. A 10 g sample of ginger powder was transferred into a 100 mL graduated cylinder and the bulk volume was recorded. The calculated bulk density was found to be 0.42

g/cm³ which falls within the typical range for herbal powders (0.3–0.5 g/cm³).

3. Tapped Density

Result:

Table No: 6 Result of Tapped Density

Sr No.	Batches	Tapped Density
1	F1	0.6 g/ml
2	F2	0.5 g/ml
3	F3	0.6 g/ml

Discussion: The tapped density was found to be 0.51 g/cm³ which is within the typical range for plant-based powders (0.4–0.6 g/cm³). This result suggests that the ginger powder has moderate compressibility, allowing it to settle efficiently with minimal air gaps between particles.

4. Physical Evaluation

Result:

Table No: 7 Result of Physical Evaluation

Sr. No	Physical Evaluation	F1	F2	F3
1.	Colour	Light Yellow	Light Yellow	Light Yellow
2.	Texture	Smooth	Smooth	Smooth

- **Discussion:** The bandages exhibited a light yellow to pale brown coloration, which can be attributed to the natural pigments and phytochemicals present in ginger extract. The surface texture of the bandages was smooth and slightly moist to touch[46].

5. pH test

Result:

Table No: 8 Result of pH Test

Sr No.	Batches	pH
1	F1	5.0-5.5
2	F2	5.0-5.6
3	F3	5.0 -5.7

Discussion: The pH of the ginger extract-based bandage formulation was determined using a calibrated digital pH meter. A 1 mL sample of the formulation was diluted in 10 mL of distilled water to ensure accurate measurement. Upon immersion of the electrode into the solution and stabilization of the reading, the pH was found to range between 5.0 and 5.7

6. Viscosity

The viscosity of the ginger extract-based bandage formulation was measured using a Oswald viscometer at 25°C. The ginger-loaded formulation exhibited a viscosity of approximately 18,700 centipoises (cP), while the base formulation without ginger extract showed a viscosity of about 12,500 cP.

7. Skin irritation test

A skin irritation test was conducted on healthy human volunteers to assess the dermal safety of the ginger extract-based bandage formulation. A small portion of the bandage was applied to a designated area of intact skin and the site was monitored for visible signs of irritation, such as redness, itching, swelling or allergic reactions over a defined observation period. The results showed that none of the subjects exhibited any symptoms of irritation or adverse skin reactions, indicating excellent dermal compatibility of the formulation.

8. Antimicrobial

The antimicrobial activity of the ginger extract-based bandage formulation was evaluated using the agar diffusion method. Test organisms such as Staphylococcus aureus (Gram-positive) and

Escherichia coli (Gram-negative) were selected due to their relevance in wound infections. The bandage sample containing ginger extract was placed on agar plates inoculated with the respective bacteria and incubated under controlled conditions.

Table No. 9 Result of Parameters

Sr No.	Parameters	Result
1	Colour	Light yellow colour
2	Texture	Slightly to touch
3	pH	5.0- 5.5
4	Viscosity	12.500cP
5	Skin irritation test	No Irritation, Redness, Swelling, Allergic Reaction

CONCLUSION

The findings of this study affirm that ginger extract is a viable natural antimicrobial agent suitable for incorporation into bandage formulations. The bioactive compounds found in ginger not only provide antibacterial protection but also contribute to anti-inflammatory and antioxidant effects essential for optimal wound healing. These attributes make ginger-based bandages a holistic approach to treating wounds, burns and post-surgical incisions. The pre-formulation and evaluation tests confirmed that the physical and chemical properties of the ginger formulation meet the standards required for medical dressings. The bandage maintained appropriate pH, viscosity and flow properties, ensuring ease of application and dermal safety. The absence of skin irritation among test subjects further supports its biocompatibility making it a safe alternative to conventional wound care products that may rely on synthetic chemicals or antibiotics.

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