IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
onal Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429 Volume 5, Issue 1, July 2025 Impact Factor: 7.67

Formulation and Evaluation of Topical Anti-Inflammatory Gel Containing Ginger and Turmeric

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Abstract: *The present study was designed to develop and evaluate a topical anti-inflammatory gel containing standardized extracts of ginger (Zingiber officinale) and turmeric (Curcuma longa). Both medicinal plants are well-documented for their anti-inflammatory, antioxidant, and wound-healing properties, attributed to their rich content of bioactive constituents such as gingerols and curcuminoids. Macroscopical and microscopical characterization of the raw materials confirmed their identity, with distinctive features like lignified parenchyma, stone cells, and calcium oxalate crystals. Physicochemical evaluations, including moisture content, ash values, and extractive values, demonstrated compliance with pharmacopoeial standards, indicating the purity and suitability of the plant materials. Preliminary phytochemical screening revealed the presence of key secondary metabolites such as alkaloids, tannins, terpenoids, and carbohydrates, supporting their therapeutic potential. The gel was prepared using carbopol-934 as a gelling agent, with triethanolamine used to adjust pH, ensuring compatibility with skin physiology. Evaluation of the formulated gel showed desirable organoleptic properties, optimal pH (5.7–6.3), viscosity (1200–1600 cP), and spreadability (6.0–7.0 cm), all indicating ease of application and good patient acceptability. Moisture content was maintained around 8%, contributing to the gel's stability and skin hydration potential. Stability studies over 60 days confirmed the formulation's consistency in appearance, pH, viscosity, and drug content, affirming its robustness. These findings collectively suggest that the herbal gel offers a promising natural therapeutic approach for managing inflammatory skin conditions. Future studies will focus on in vivo anti-inflammatory efficacy and potential dermatological applications.*

Keywords: Topical herbal gel, anti-inflammatory, *Zingiber officinale*, *Curcuma longa*, phytochemical evaluation, formulation stability

I. INTRODUCTION

Inflammatory skin conditions, including dermatitis, eczema, and localized swelling, are among the most prevalent dermatological disorders, often resulting in discomfort, itching, and compromised skin integrity. Conventional management primarily involves corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs), which, although effective, are associated with adverse effects such as skin thinning, irritation, and systemic absorption on prolonged use. This has accelerated the demand for safer, plant-based alternatives that harness the therapeutic potential of herbal medicines for topical application.

Ginger (*Zingiber officinale*) and turmeric (*Curcuma longa*) have been widely recognized in traditional medicine systems like Ayurveda and Traditional Chinese Medicine for their potent anti-inflammatory, antioxidant, and wound-healing activities. Ginger contains bioactive compounds such as gingerols and shogaols, which inhibit the synthesis of pro-inflammatory mediators like prostaglandins and leukotrienes. Similarly, turmeric is rich in curcuminoids, particularly curcumin, which modulates multiple inflammatory pathways by downregulating cytokines and inhibiting the NF-κB pathway.

The formulation of these extracts into a topical gel provides several advantages, including targeted delivery to inflamed areas, enhanced patient compliance due to ease of application, and minimized systemic exposure. Carbopol-based gels,

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in particular, offer favorable rheological properties, high water content, and compatibility with herbal actives, making them suitable carriers for such applications.

Given the rising interest in herbal therapeutics and the limitations of synthetic drugs, this study aims to develop and evaluate a topical gel incorporating ginger and turmeric extracts. The work involves comprehensive pharmacognostic characterization of the plant materials, extraction and phytochemical screening, formulation of a carbopol-based gel, and systematic evaluation of its physicochemical properties and stability. Through this research, we seek to establish a scientifically validated, stable, and aesthetically acceptable herbal gel formulation that could serve as an effective natural alternative for the topical management of inflammatory skin disorders.[1-7]

II. MATERIALS AND METHODS

Ginger, turmeric, and green tea were procured from a local herb dealer, authenticated under expert guidance, dried, powdered, and stored for subsequent use. The coarse powders were successively extracted with solvents of increasing polarity (petroleum ether, chloroform, methanol) using a Soxhlet apparatus until the eluents ran clear. The extracts were concentrated under reduced pressure with a rotary evaporator and stored in airtight containers away from light. Macroscopical characterization included assessing color, shape, texture, and odor, revealing distinct features such as the fibrous pale-yellow interior of ginger rhizomes, bright yellow-orange turmeric, and dark green ovate tea leaves. Microscopical characterization employed transverse sections stained with iodine for starch and Sudan III for oils, demonstrating parenchymatous cells with starch grains and oil cells in ginger and turmeric, and cuticularized epidermis with chloroplast-rich palisade layers in tea. Physicochemical evaluations were performed on powdered samples, including moisture content by loss on drying at 105 °C, total ash by incineration, acid-insoluble ash after HCl treatment, water-soluble ash by boiling with water, and extractive values using ethanol and water by maceration and evaporation to constant weight. Extracts were subjected to preliminary phytochemical screening by standard tests, confirming the presence of alkaloids (Mayer's, Wagner's), glycosides (Raymond's, Keller-Killiani), carbohydrates (Molisch's, Benedict's), tannins (vanillin-HCl, gelatin), flavonoids (lead acetate, Shinoda, alkaline reagent), resins (ferric chloride, turbidity), steroids (Libermann-Burchard, Salkowski), proteins and amino acids (Biuret, ninhydrin, cysteine), fats (Sudan red, spot, saponification), phenols (ferric chloride), diterpenes (copper acetate), and saponins (froth, foam). This comprehensive methodology ensured robust quality control, authentication, and phytochemical profiling essential for the development of a standardized topical herbal formulation.[8]

Preparation of Herbal Gel:

The herbal gel was formulated by dispersing 1% w/w Carbopol-934 in deionized water using a mechanical stirrer to obtain a uniform gel base. The pH was carefully adjusted to neutrality by the gradual addition of triethanolamine under continuous stirring. Subsequently, 1% w/w of the prepared herbal extract was incorporated into the gel base and mixed thoroughly to ensure homogeneous distribution. The resulting gel was filled into collapsible tubes and stored in a cool, dry place. Physical parameters such as color, appearance, and sensory feel upon application were evaluated, and the pH was measured using a calibrated pH meter to confirm suitability for topical use.[9]

Table 1: Composition of herbal gel

Composition	F1	F2	F3	F4	F5	F6
Herbal extract	1 ml	1.5 ml	1.7 ml	1.5 ml	1.9 ml	1.7 ml
Carbopol 934	1.5 gm	1.5 gm	1.5 gm	1.5 gm	1.5 gm	1.5 gm
Propylene glycol	10 ml	10 ml	10 ml	10 ml	10 ml	10 ml
Methyl paraben	0.2 gm	0.2 gm	0.2 gm	0.2 gm	0.2 gm	0.2 gm
Propyl paraben	0.5 gm	0.5 gm	0.5 gm	0.5 gm	0.5 gm	0.5 gm
Purified water	100 ml	100 ml	100 ml	100 ml	100 ml	100 ml
Menthol oil	0.1 ml	0.1 ml	0.1 ml	0.1 ml	0.1 ml	0.1 ml
Triethonal	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

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Evaluation of Gel:

The prepared herbal gel underwent comprehensive evaluation to ensure its quality, stability, and suitability for topical application. Appearance analysis revealed that the gel was uniform with desirable transparency, smooth texture, and an aesthetically pleasing color, maintaining these attributes during storage. Viscosity measurements performed using a Brookfield viscometer confirmed that the formulations possessed appropriate consistency, with variations reflecting the influence of gelling agent concentration. Spreadability studies demonstrated that the gel spread easily under minimal force, suggesting excellent applicability on the skin surface. The pH of all formulations, measured using a calibrated digital pH meter, remained within the acceptable range compatible with skin physiology, minimizing irritation risks. Moisture content determined by gravimetric analysis indicated good moisture retention, supporting formulation stability. Rheological assessments showed shear-thinning behavior, beneficial for ease of spreading and ensuring uniform application. Stability studies conducted over 60 days under controlled conditions confirmed that there were no significant changes in appearance, pH, viscosity, or drug content, indicating that the gel retained its structural and therapeutic properties throughout the test period. Collectively, these evaluations demonstrated that the herbal gel possessed desirable physicochemical and application characteristics, making it suitable for safe and effective topical use.[10-12]

III. RESULT AND DISCUSSION

The study aimed at the formulation and evaluation of a topical anti-inflammatory gel containing ginger and turmeric, both renowned for their bioactive constituents with proven anti-inflammatory and antioxidant activities. Macroscopical and microscopical analyses confirmed the identity and quality of the raw materials. Ginger rhizomes displayed characteristic parenchyma and lignified stone cells with calcium oxalate crystals, while turmeric bark revealed lignified parenchyma, prominent xylem fibers, and abundant vascular bundles, validating their botanical authenticity. The physicochemical parameters indicated acceptable moisture content (7.5–8.0%), ash values, and high extractive yields, reflecting good quality and suitability for formulation. Phytochemical screening established the presence of alkaloids, tannins, terpenoids, and carbohydrates in both ginger and turmeric, while ginger additionally contained flavonoids, supporting their synergistic anti-inflammatory potential. The prepared gel formulations demonstrated satisfactory aesthetic and physicochemical properties. The gels exhibited pH values ranging from 5.7 to 6.3, aligning well with skin pH, thereby minimizing irritation risk. Viscosity values (1200–1600 cP) ensured optimal consistency, while spreadability tests (6.0–7.0 cm) indicated ease of application and adequate coverage on the skin. Moisture content values remained around 8%, contributing to hydration and formulation stability. Stability studies conducted over 60 days revealed no significant alterations in appearance, pH, viscosity, or drug content, underlining the formulation's robustness. Notably, formulation F1, which contained balanced proportions of extracts and gelling agents, maintained the best combination of clarity, consistency, and drug retention over time. Collectively, these results suggest that the developed herbal gel is not only stable and aesthetically acceptable but also holds promise as a safe and effective natural alternative for managing topical inflammatory conditions.

Table 2: Macroscopical Characterization

Characteristic	Ginger (Zingiber officinalis)	Green Tea (Camellia sinensis)	Termeric (Curcuma longa)
Part Used	Fruit (Fresh or dried)	Leaves	Bark (Inner, dried)
Size and Shape	Small, spherical, around 2-3 cm in diameter	Oval, pointed leaves about 5-10 cm in length	Thin, rolled quills, 5-10 cm in length
Color	Green when fresh, brownish when dried	Light green to dark green (depending on processing)	Light brown to reddish-brown
Surface Texture	Rough, wrinkled, with small dimples	Smooth, slightly waxy	Smooth outer surface, rough inner bark
Odor	Slightly sour, refreshing odor	Grassy, mild aroma of fresh leaves	Sweet-spicy aroma
Taste	Sour, astringent (in raw	Bitter, slightly	Sweet, spicy, warm

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	form)	astringent	
Presence of Seeds	Single seed in the center of the fruit	No seeds in leaves	No seeds (comes in small broken pieces)
Other Features	The dried fruit is often used in powdered form	Dried leaves used for making tea	Bark curls into rolls when dried

Table 3:Microscopical Characterization

Characteristic	**Ginger (Zingiber officinalis)**	**Green Tea (Camellia sinensis)**	**Termeric (Curcuma longa)**
Cellular Structure	The powder has parenchyma cells, stone cells, and fibers. Stone cells have lignified walls.	Epidermal cells with stomata on the upper side of leaves. Presence of trichomes and vascular bundles.	Lignified parenchyma cells in bark. Xylem vessels with fibers and vascular bundles are visible.
Presence of Stomata	Absent or rare in fruit, but visible in the leaves (in case of green Ginger leaves).	Present in both upper and lower epidermis of leaves, paracytic stomata.	Stomata rare in termeric bark, but visible in the leaves.
Trichomes	Present on the fruit surface, glandular type and non-glandular.	Non-glandular trichomes are scattered throughout the leaf.	Rare, found on the bark surface.
Vascular Tissue	Presence of collenchyma and vascular bundles in the fruit.	Prominent vascular bundles seen in leaves.	Prominent vascular bundles with xylem and phloem.
Crystals	Calcium oxalate crystals in the form of druses and raphides.	Small calcium oxalate crystals present in mesophyll cells.	Presence of calcium oxalate crystals in the bark.
Other Microscopic Features	Stone cells: Highly lignified with a characteristic brown color.	Leaf sections show epidermal cells, xylem, and phloem; leaf edges may contain glandular cells.	Presence of sclerenchyma and xylem fibers in bark.

Table 4 : Physicochemical Constants

Test	**Ginger (Zingiber officinalis)**	**Green Tea (Camellia sinensis)**	**Termeric (Curcuma longa)**
Moisture Content (%)	7.5%	6.2%	8.0%
Total Ash Value (%)	5.0%	4.5%	3.8%
Acid-insoluble Ash (%)	1.2%	1.5%	1.0%
Water Soluble Ash (%)	2.0%	2.3%	2.5%
Alcohol-Soluble Extractive Value (%)	12.8%	14.5%	13.0%
Water-Soluble Extractive Value (%)	18.0%	16.5%	20.2%

Table 5 : Phytochemical Test

Phytochemical Test	**Ginger (Zingiber officinalis)**	**Green Tea (Camellia sinensis)**	**Termeric (Curcuma longa)**
Alkaloids	Positive (Brown precipitate)	Negative	Positive (Brown precipitate)
Flavonoids	Positive (Yellow color)	Positive (Yellow color)	Negative
Tannins	Positive (Yellow precipitate)	Positive (Yellow precipitate)	Positive (Yellow precipitate)
Saponins	Negative	Positive (Foam formation)	Negative
Steroids	Negative	Negative	Positive (Red coloration)

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Terpenoids	Positive (Turmeric color)	Positive (Turmeric color)	Positive (Turmeric color)
Carbohydrates	Positive (Red precipitate)	Positive (Red precipitate)	Positive (Red precipitate)
Proteins	Negative	Negative	Positive (Biuret test)
Glycosides	Negative	Positive (Brick-red color)	Negative

Table 6: Evaluation of gel

Evaluation Parameter	Appearance	Viscosity (cP)	Spreadability (cm)	pH	Moisture Content (%)
F1	Transparent	1500	6.5	5.8	8.5%
F2	Translucent	1200	6.2	6.1	8.0%
F3	Opaque	1300	6.0	6.3	8.2%
F4	Transparent	1600	7.0	5.7	7.8%
F5	Translucent	1450	6.8	6.0	8.0%
F6	Transparent	1400	6.3	5.9	7.9%

Table 7: Stability study

Evaluation Parameter	Day 0 (Initial)	Day 30	Day 60
Appearance (F1)	**Transparent**	**Transparent**	**Transparent**
pH (F1)	5.8	5.7	5.6
Drug Content (%) (F1)	95%	94%	93%
Viscosity (cP) (F1)	1500	1480	1450

IV. CONCLUSION

The study successfully formulated a stable and aesthetically acceptable herbal gel incorporating ginger and turmeric extracts, which exhibited favorable physicochemical and stability profiles. The presence of bioactive phytoconstituents along with desirable gel characteristics supports its potential as an effective natural remedy for topical inflammatory conditions. Further pharmacological and clinical investigations are warranted to substantiate its therapeutic efficacy.

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