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Formulation and Invitro Evaluation of Herbal Gel

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Abstract: *Herbal formulations have gained considerable importance in modern pharmaceutical and cosmetic industries due to their safety, effectiveness, and minimal side effects. The present project focuses on the formulation and in-vitro evaluation of herbal gel using natural plant extracts possessing antimicrobial, anti-inflammatory, and antioxidant activities. Herbal gels provide better patient compliance, ease of application, non-greasy nature, and improved drug release characteristics compared to ointments and creams.*

The herbal gel was prepared using suitable gelling agents such as Carbopol 934 and herbal extracts like Aloe vera, Neem, Turmeric, and Green tea extract. Different formulations were prepared by varying polymer concentration and evaluated for physicochemical properties including appearance, pH, viscosity, spreadability, homogeneity, extrudability, drug content, and in-vitro diffusion study. Stability studies were also performed under different storage conditions.

The results indicated that the optimized formulation showed good consistency, satisfactory spreadability, acceptable pH, and enhanced drug release. The herbal gel demonstrated excellent stability and therapeutic potential for topical application..

Keywords: Herbal gel, Carbopol, Aloe vera, Neem, In-vitro diffusion, Topical formulation

I. INTRODUCTION

1.1 Introduction to Herbal Drug Delivery System

Herbal drug delivery systems are pharmaceutical formulations containing active constituents obtained from plants and natural sources. Since ancient times, medicinal plants have been widely used for the prevention and treatment of diseases because of their therapeutic effectiveness and lower side effects compared to synthetic drugs. Herbal medicines are considered safer, economical, and easily available.

The World Health Organization (WHO) has reported that a large population in developing countries depends on herbal medicines for primary healthcare. Herbal preparations are available in different dosage forms such as tablets, capsules, syrups, ointments, creams, and gels.

Modern herbal formulations aim to improve stability, patient compliance, bioavailability, and therapeutic efficacy. Herbal gels are among the most commonly used topical herbal preparations because they are non-greasy, easily washable, and provide better drug release.

1.2 Introduction to Topical Drug Delivery System

Topical drug delivery refers to the application of medicaments directly onto the skin or mucosal membrane to produce local or systemic effects. Topical preparations are mainly used to treat skin disorders such as acne, burns, fungal infections, wounds, inflammation, and allergies.

The skin acts as a protective barrier against environmental factors and microorganisms. For a drug to produce therapeutic action, it must penetrate through different layers of the skin.

Common topical dosage forms include:

1. Ointments
2. Creams
3. Lotions

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4. Pastes
5. Gels

Topical drug delivery systems offer several advantages such as targeted action, reduced systemic side effects, improved patient compliance, and ease of application.

1.3 Anatomy and Physiology of Skin

The skin is the largest organ of the human body and serves as a protective barrier. It performs several important functions including temperature regulation, prevention of water loss, sensory perception, and protection against pathogens.

The skin consists of three major layers:

1.3.1 Epidermis

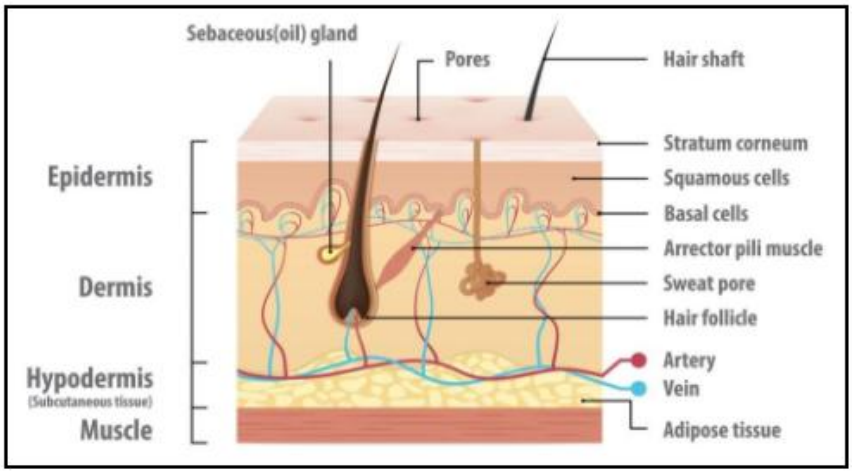
The epidermis is the outermost layer of the skin. It contains keratinized cells and acts as a protective barrier. The stratum corneum is the outer layer of the epidermis and is mainly responsible for controlling drug penetration.

1.3.2 Dermis

The dermis lies below the epidermis and contains blood vessels, nerves, hair follicles, sweat glands, and sebaceous glands. It provides nourishment and strength to the skin.

1.3.3 Hypodermis

The hypodermis or subcutaneous tissue is the innermost layer composed mainly of fat cells. It acts as an insulating and cushioning layer.



Functions of Skin

1. Protection from microorganisms
2. Regulation of body temperature
3. Sensory perception
4. Prevention of dehydration
5. Vitamin D synthesis

1.4 Introduction to Gels

Gels are semisolid dosage forms in which solid particles or polymers are dispersed in a liquid phase. They possess a three-dimensional network structure that provides consistency and stability.

Gels are transparent or translucent preparations used for both pharmaceutical and cosmetic purposes. They are widely used in topical drug delivery because they provide cooling sensation, ease of spreadability, and good patient acceptability.

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Characteristics of Ideal Gel

1. Smooth appearance
2. Non-greasy nature
3. Easily washable
4. Good spreadability
5. Non-irritant
6. Stable during storage

1.5 Introduction to Herbal Gel

Herbal gel is a semisolid topical formulation containing herbal extracts incorporated into a suitable gel base. Herbal gels combine the therapeutic benefits of medicinal plants with the advantages of gel formulations.

The use of herbal gels has increased due to growing awareness regarding the adverse effects of synthetic drugs. Herbal gels are commonly used for anti-inflammatory, antimicrobial, antiacne, wound healing, and antifungal purposes.

Commonly used herbal ingredients include:

1. Aloe vera
2. Neem
3. Turmeric

These herbal ingredients possess pharmacological activities such as antimicrobial, antioxidant, and anti-inflammatory effects.

1.6 Advantages of Herbal Gel

1. Easy to apply and remove
2. Non-sticky and non-greasy
3. Better patient compliance
4. Improved drug release
5. Cooling and soothing effect

1.7 Disadvantages of Herbal Gel

1. Possibility of microbial contamination
2. Stability problems due to natural constituents
3. Chances of allergic reactions in sensitive individuals

1.8 Classification of Gels

Based on Physical Nature

1. Single-phase gels
2. Two-phase gels

Based on Solvent Used

1. Hydrogels
2. Organogels

Based on Route of Administration

1. Topical gels
2. Ophthalmic gels
3. Nasal gels
4. Oral gels

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1.9 Polymers Used in Gel Formulation

Polymers play an important role in determining viscosity, consistency, and stability of gels.

Commonly Used Gelling Agents

1. Carbopol 934
2. HPMC (Hydroxy Propyl Methyl Cellulose)
3. Sodium alginate
4. Xanthan gum
5. Guar gum
6. Tragacanth

Carbopol is the most widely used polymer because it produces clear and stable gels with good viscosity.

1.10 Herbal Drugs Used in Formulation

1.10.1 Aloe Vera

Biological Source

Obtained from leaves of Aloe barbadensis Miller.

Uses

1. Moisturizing agent
2. Wound healing
3. Anti-inflammatory action
4. Antimicrobial activity

1.10.2 Neem

Biological Source

Leaves of Azadirachta indica.

Uses

1. Antibacterial activity
2. Antifungal action
3. Anti-acne effect
4. Skin cleansing action

1.10.3 Turmeric

Biological Source

Rhizomes of Curcuma longa.

Uses

1. Antioxidant activity
2. Anti-inflammatory effect
3. Antimicrobial property
4. Wound healing activity

1.11 Mechanism of Drug Penetration Through Skin

Drug penetration through the skin mainly occurs by passive diffusion. The drug penetrates through the stratum corneum and reaches deeper layers of the skin.

Pathways of Drug Absorption

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1. Transcellular pathway
2. Intercellular pathway
3. Follicular pathway

Factors affecting penetration include:

1. Molecular size
2. Lipid solubility
3. Concentration gradient
4. Skin hydration
5. pH of formulation

1.12 Applications of Herbal Gel

1. Treatment of acne
2. Wound healing
3. Burns and cuts
4. Fungal infections
5. Skin inflammation
6. Anti-aging preparations
7. Cosmetic formulations
8. Moisturizing products

II. REVIEW OF LITERATURE

2.1 Overview

Literature review is an important part of research work that provides information regarding previous studies carried out on similar formulations. It helps in understanding formulation techniques, evaluation parameters, therapeutic applications, and recent advancements related to herbal gel preparations. Herbal gels have gained significant attention due to their enhanced patient compliance, non-greasy nature, ease of application, and improved therapeutic effectiveness. Various medicinal plants possessing antimicrobial, anti-inflammatory, antioxidant, and wound healing activities have been incorporated into gel formulations for topical treatment of skin disorders.

2.2 Review of Previous Research Work

Study 1

Patel et al. formulated and evaluated an Aloe vera herbal gel using Carbopol 934 as a gelling agent. The prepared gel exhibited satisfactory viscosity, good spreadability, acceptable pH, and significant antimicrobial activity against skin pathogens. The study concluded that Aloe vera gel could be effectively used for topical treatment of skin irritation and wounds.

Study 2

Sharma et al. prepared a polyherbal gel containing Neem and Turmeric extracts for anti-acne activity. The formulation showed excellent antibacterial action against Propionibacterium acnes and Staphylococcus aureus. The gel demonstrated good homogeneity and stability during storage.

Study 3

Kumar et al. developed herbal gel containing Green tea extract and evaluated its antioxidant potential. The study reported that the gel possessed significant free radical scavenging activity and improved skin hydration properties.

Study 4

Singh et al. formulated herbal gel using Tulsi extract and Carbopol polymer. The formulation exhibited good consistency, non-irritancy, and effective antimicrobial action against fungal and bacterial species.

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2.3 Role of Herbal Drugs in Topical Preparations

Medicinal plants contain bioactive constituents such as alkaloids, flavonoids, tannins, glycosides, terpenoids, and phenolic compounds which possess therapeutic activities.

Important Herbal Drugs Used in Gel Formulations

Herbal Drug	Major Activity
Aloe vera	Wound healing, moisturizing
Neem	Antibacterial, antifungal
Turmeric	Anti-inflammatory, antioxidant

These herbal ingredients are commonly used in topical formulations because they provide therapeutic benefits with minimal side effects.

2.4 Advantages of Herbal Formulations Over Synthetic Preparations

1. Safer and less toxic
2. Reduced chances of skin irritation
3. Better patient acceptance
4. Cost-effective therapy
5. Easily available raw materials
6. Eco-friendly formulations
7. Better compatibility with skin

III. AIM AND OBJECTIVES

3.1 Aim of the Study

To formulate and evaluate herbal gel for topical application using selected herbal extracts and suitable gelling agents.

3.2 Objectives of the Study

Primary Objectives

1. To prepare herbal gel using selected medicinal plant extracts.
2. To develop a stable and effective topical gel formulation.
3. To evaluate the physicochemical properties of prepared herbal gel.
4. To study the in-vitro drug diffusion profile of the formulation.
5. To optimize gel formulation based on evaluation parameters.

Secondary Objectives

1. To study the role of herbal ingredients in topical therapy.
2. To select suitable polymers for gel preparation.
3. To determine the compatibility of herbal extracts with excipients.
4. To improve spreadability and consistency of gel formulation.
5. To evaluate stability of the prepared formulation under different storage conditions.

3.3 Plan of Work

The present investigation was planned systematically to formulate and evaluate herbal gel.

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Planned of Work
1. Selection of herbal ingredients
2. Procurement of chemicals and excipients
3. Preparation of herbal extracts
4. Formulation of gel base
5. Incorporation of herbal extracts into gel base
6. Optimization of formulation parameters
7. Evaluation of prepared formulations
8. Stability studies of optimized formulation

3.4 Need for the Present Study

Synthetic topical preparations may produce undesirable side effects such as:
1. Skin irritation
2. Dryness
3. Allergic reactions
4. Burning sensation

Herbal formulations provide safer alternatives with better therapeutic acceptability. However, formulation challenges such as stability, consistency, and drug release need to be addressed.

Therefore, the present work was undertaken to formulate a stable and effective herbal gel with satisfactory physicochemical properties and enhanced in-vitro performance.

3.5 Expected Outcome

The study is expected to:
1. Produce stable herbal gel formulation
2. Show good spreadability and viscosity
3. Provide satisfactory drug release profile
4. Demonstrate acceptable pH and homogeneity
5. Enhance topical therapeutic effectiveness

IV. PLANT PROFILE

4.1 Overview

Medicinal plants are rich sources of bioactive phytoconstituents that possess various pharmacological activities including antimicrobial, antioxidant, anti-inflammatory, anticancer, and antiviral properties. The antimicrobial activity of medicinal plants is mainly attributed to secondary metabolites such as alkaloids, flavonoids, tannins, terpenoids, glycosides, and phenolic compounds. In the present study, selected medicinal plants known for their antimicrobial properties were chosen for extraction and evaluation against pathogenic microorganisms. The selected plants include:
• Neem (Azadirachta indica)
• Turmeric (Curcuma longa)
• Aloe vera (Aloe barbadensis)

These plants have been widely used in traditional systems of medicine such as Ayurveda, Siddha, and Unani for the treatment of infectious diseases.

4.2 Neem (Azadirachta indica)

Biological Source:
Neem consists of fresh and dried leaves obtained from Azadirachta indica. Scientific Classification

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Category	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Sapindales
Family	Meliaceae
Genus	Azadirachta
Species	indica

Neem (Azadirachta indica)

Geographical Source

Neem is widely distributed throughout India, Bangladesh, Sri Lanka, and tropical regions of Africa.

Morphological Characteristics

- Medium to large evergreen tree
- Height: 12–20 meters
- Leaves are pinnate and green
- Flowers are white and fragrant
- Fruits are oval-shaped drupes

Chemical Constituents

Neem contains several biologically active compounds including:

- Azadirachtin
- Nimbin
- Nimbidin
- Quercetin
- Flavonoids
- Tannins
- Alkaloids

The antimicrobial activity is mainly due to flavonoids and limonoids.

Uses

- Skin infections
- Wound healing
- Dental infections
- Fever

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• Fungal infections

4.3 Turmeric (Curcuma longa)

Biological Source

Turmeric consists of dried rhizomes of Curcuma longa.

Scientific Classification

Category	Classification
Kingdom	Plantae
Family	Zingiberaceae
Genus	Curcuma
Species	longa

Turmeric (Curcuma longa)

Morphological Characteristics

• Perennial herb
• Yellow-orange rhizomes
• Broad leaves
• Aromatic odor

Chemical Constituents

• Curcumin
• Turmerone
• Demethoxycurcumin
• Essential oils

Uses

• Wound healing
• Skin infections
• Gastrointestinal disorders
• Inflammatory diseases

4.4 Aloe vera (Aloe barbadensis)

Biological Source

Aloe vera consists of fresh leaves of Aloe barbadensis.

Scientific Classification

Category	Classification
Kingdom	Plantae

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Family	Asphodelaceae
Genus	Aloe
Species	barbadensis

Aloe vera (Aloe barbadensis)

Morphological Characteristics
• Succulent perennial herb
• Thick fleshy leaves
• Gel-filled leaf interior
• Green spiny leaves
Chemical Constituents
• Aloin
• Anthraquinones
• Saponins
• Vitamins
• Minerals
Uses
• Burns
• Wounds
• Skin infections
• Cosmetic preparations

4.7 Comparison of Selected Medicinal Plants

Plant	Major Constituents	Main Activity
Neem	Azadirachtin, Nimbin	Antibacterial
Turmeric	Curcumin	Anti-inflammatory
Aloe vera	Anthraquinones	Wound healing

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4.8 Importance of Selected Plants in Antimicrobial Research

The selected medicinal plants are widely used in traditional medicine and possess scientifically proven antimicrobial properties. These plants are economical, easily available, and rich in bioactive compounds capable of inhibiting pathogenic microorganisms.

V. MATERIALS AND METHODS

5.1 Materials Required Herbal Ingredients

1. Aloe vera extract
2. Neem extract
3. Turmeric extract

Polymers and Excipients

1. Carbopol 934
2. Glycerin
3. Triethanolamine (TEA)
4. Methyl paraben
5. Propyl paraben
6. Distilled water

5.2 List of Chemicals and Their Uses

Material	Category	Use
Aloe vera extract	Herbal drug	Wound healing and moisturizing
Neem extract	Herbal drug	Antimicrobial activity
Turmeric extract	Herbal drug	Anti-inflammatory activity
Carbopol 934	Polymer	Gelling agent
Glycerin	Humectant	Moisturizing agent
TEA	Neutralizer	pH adjustment
Methyl paraben	Preservative	Prevent microbial growth
Propyl paraben	Preservative	Stability enhancement
Distilled water	Vehicle	Preparation medium

5.3 Equipment Used

Equipment	Purpose
Digital balance	Accurate weighing
Magnetic stirrer	Mixing of ingredients
pH meter	pH determination
Brookfield viscometer	Viscosity measurement
Glass beakers	Preparation of gel
Measuring cylinder	Volume measurement
Mortar and pestle	Mixing and grinding
Franz diffusion cell	In-vitro diffusion study
UV spectrophotometer	Drug content analysis

5.4 Methodology

The methodology adopted for the preparation of herbal gel included:

1. Collection of herbal materials

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2. Drying and powdering
3. Preparation of herbal extracts
4. Formulation of gel base
5. Incorporation of herbal extracts
6. Evaluation of prepared gel

5.5 Collection and Authentication of Herbal Materials

Fresh herbal materials such as Aloe vera leaves, Neem leaves, and Turmeric rhizomes were collected from local sources. The plant materials were identified and authenticated by a qualified botanist or pharmacognosist.

The collected materials were washed thoroughly with water to remove dirt and impurities.

5.6 Drying and Powdering of Herbal Materials

The collected plant materials were shade dried at room temperature for several days to remove moisture content.

After complete drying:

1. Neem leaves were powdered using grinder.
2. Turmeric rhizomes were crushed into coarse powder.
3. Aloe vera gel was separated from leaves for extraction.

The powdered materials were stored in airtight containers.

5.7 Preparation of Herbal Extracts

Preparation of Neem Extract

1. Dried Neem powder was weighed accurately.
2. The powder was soaked in suitable solvent such as ethanol or distilled water.
3. The mixture was kept for maceration for 24–48 hours.
4. The extract was filtered using muslin cloth and filter paper.
5. Filtrate was concentrated by evaporation.

Preparation of Turmeric Extract

1. Turmeric powder was extracted using ethanol.
2. The extract was filtered and concentrated.
3. Concentrated extract was stored for further use.

Preparation of Aloe Vera Gel

1. Fresh Aloe vera leaves were washed thoroughly.
2. Outer covering was removed carefully.
3. Transparent gel portion was collected.
4. Gel was homogenized to obtain uniform consistency.

5.8 Preparation of Gel Base

Procedure

1. Required quantity of Carbopol 934 was weighed accurately.
2. Carbopol was slowly dispersed in distilled water with continuous stirring.
3. The dispersion was allowed to hydrate completely for 1–2 hours.
4. Glycerin was added slowly to improve smoothness and moisturizing property.

5.9 Preparation of Herbal Gel

Procedure

1. Prepared herbal extracts were added slowly into gel base with continuous stirring.

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2. Methyl paraben and propyl paraben were dissolved separately and incorporated into formulation.
3. Triethanolamine was added dropwise to neutralize Carbopol and form gel structure.
4. Continuous stirring was carried out to obtain homogeneous gel.
5. Final gel was transferred into suitable airtight containers.

Flow Chart of Herbal Gel Preparation

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5.10 Formulation Design

Ingredients	F1	F2	F3
Aloe vera extract	2%	3%	4%
Neem extract	1%	1%	1%
Turmeric extract	0.5%	0.5%	0.5%
Carbopol 934	1%	1.5%	2%
Glycerin	5%	5%	5%
TEA	q.s	q.s	q.s
Distilled water	q.s	q.s	q.s

5.11 Evaluation Parameters

The prepared herbal gels were evaluated for the following parameters:

1. Physical appearance
2. pH determination
3. Homogeneity
4. Spreadability
5. Viscosity
6. Extrudability
7. Drug content
8. In-vitro diffusion study
9. Stability studies

5.12 pH Determination

The pH of gel formulations was measured using digital pH meter.

Procedure

1. One gram of gel was dispersed in distilled water.
2. pH meter electrode was dipped into sample.
3. Reading was recorded after stabilization.

An ideal topical gel should possess pH near skin pH to avoid irritation.

VI. FORMULATION DEVELOPMENT

6.1 Objectives of Formulation Development

1. To prepare stable herbal gel formulations
2. To optimize concentration of gelling agent
3. To improve spreadability and consistency
4. To achieve acceptable pH and viscosity
5. To enhance drug release profile
6. To obtain homogeneous and non-irritant formulation

6.2 Selection of Ingredients

The ingredients used in formulation development were selected based on their therapeutic and pharmaceutical properties.

Herbal Ingredients

Aloe Vera

Selected for:

1. Moisturizing property

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2. Wound healing activity
3. Anti-inflammatory effect

Neem

Selected for:

1. Antibacterial activity
2. Antifungal property
3. Anti-acne effect

Turmeric

Selected for:

1. Antioxidant activity
2. Anti-inflammatory action
3. Skin protective effect

Excipients Used Carbopol 934

Used as:

1. Gelling agent
2. Thickening agent
3. Stabilizer Glycerin

Used as:

1. Humectant
2. Moisturizer
3. Smoothing agent Triethanolamine

Used for:

1. Neutralization of Carbopol
2. pH adjustment
3. Gel formation

Methyl Paraben and Propyl Paraben

Used as preservatives to prevent microbial contamination.

6.3 Preformulation Studies

Preformulation studies were carried out before formulation development to evaluate compatibility and characteristics of ingredients.

Parameters Evaluated

1. Color and appearance
2. Solubility of extracts
3. Compatibility with polymer
4. Stability of extracts
5. pH of herbal extracts

No significant incompatibility was observed between herbal extracts and excipients.

6.4 Method of Preparation of Herbal Gel

Step 1: Preparation of Polymer Dispersion

1. Required quantity of Carbopol 934 was weighed accurately.
2. Carbopol was slowly added into distilled water with continuous stirring.
3. The mixture was allowed to stand for hydration.

Step 2: Preparation of Herbal Extract Mixture

1. Aloe vera gel was collected and homogenized.
2. Neem extract and Turmeric extract were prepared separately.
3. All herbal extracts were mixed uniformly.

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Step 3: Addition of Excipients

1. Glycerin was added to improve smoothness.
2. Preservatives were dissolved separately and added to formulation. Step 4: Formation of Herbal Gel
1. Herbal extract mixture was added into polymer dispersion slowly.
2. Triethanolamine was added dropwise with continuous stirring.
3. Neutralization of Carbopol resulted in gel formation.
4. Final gel was mixed thoroughly to obtain homogeneous consistency.

6.5 Formulation Design

Three formulations were prepared with different concentrations of Carbopol 934 and herbal extracts.

Formulation Table

Ingredients	F1	F2	F3
Aloe vera extract	2%	3%	4%
Neem extract	1%	1%	1%
Turmeric extract	0.5%	0.5%	0.5%
Carbopol 934	1%	1.5%	2%
Glycerin	5%	5%	5%
Methyl paraben	0.1%	0.1%	0.1%
Propyl paraben	0.05%	0.05%	0.05%
TEA	q.s	q.s	q.s
Distilled water	q.s to 100 g	q.s to 100 g	q.s to 100 g

6.7 Optimization of Formulation

Optimization was carried out by comparing evaluation parameters of different formulations.

Parameters Considered for Optimization

1. Physical appearance
2. Homogeneity
3. Spreadability
4. pH
5. Viscosity
6. Extrudability
7. Drug release profile
8. Stability

The formulation showing best overall performance was selected as optimized formulation.

6.8 Mechanism of Gel Formation

Carbopol 934 is a cross-linked polyacrylic acid polymer. When dispersed in water, it swells and forms a viscous dispersion.

Addition of Triethanolamine neutralizes acidic groups of Carbopol, resulting in expansion of polymer chains and formation of gel network structure.

The mechanism improves:

1. Viscosity
2. Consistency
3. Stability
4. Spreadability

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VII. EVALUATION PARAMETERS

Evaluation of pharmaceutical formulations is essential to determine their quality, stability, effectiveness, and patient acceptability. In herbal gel formulations, various physicochemical and in-vitro parameters are evaluated to ensure that the prepared gel possesses suitable characteristics for topical application.

7.1 Purpose of Evaluation Studies

The evaluation studies were carried out for the following purposes:

1. To determine quality and consistency of gel
2. To evaluate physical stability of formulation
3. To assess spreadability and ease of application
4. To determine viscosity and flow behavior
5. To evaluate drug release profile
6. To ensure compatibility with skin pH
7. To optimize formulation performance

7.2 Physical Appearance

Objective

To evaluate the visual appearance and texture of prepared gel formulations. Procedure

The prepared gels were visually inspected for:

1. Color
2. Odor
3. Transparency
4. Consistency
5. Presence of lumps

Observation

An ideal herbal gel should possess:

1. Smooth texture
2. Pleasant appearance
3. Uniform consistency
4. Absence of particulate matter

7.3 Homogeneity

Objective

To determine uniform distribution of ingredients in gel formulation.

Procedure

A small quantity of gel was pressed between thumb and index finger and visually observed for uniformity and smoothness.

Observation

The gel should be:

1. Homogeneous
2. Free from aggregates
3. Smooth in texture

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7.4 Determination of pH

Objective

To determine pH of herbal gel and ensure compatibility with skin. Principle pH of topical formulations should be near skin pH to avoid irritation.

Procedure

1. One gram of gel was dissolved in 100 ml distilled water.
2. The solution was stirred thoroughly.
3. pH was measured using calibrated digital pH meter.

Observation

The ideal pH range for topical gel is: 6.0–7.0

7.5 Viscosity Determination

Objective

To determine flow behavior and consistency of gel.

Principle

Viscosity indicates resistance to flow and affects spreadability and drug release.

Procedure

1. Gel sample was placed in beaker.
2. Brookfield viscometer was used for measurement.
3. Appropriate spindle was selected.
4. Readings were recorded at specified RPM.

Importance

1. Determines consistency
2. Affects drug diffusion
3. Influences patient acceptability

7.6 Spreadability Study

Objective

To determine ease of spreading of gel on skin surface.

Principle

Spreadability indicates the extent to which gel spreads on application.

Procedure

1. Excess gel was placed between two glass slides.
2. A known weight was placed on upper slide.
3. Time required to move upper slide was noted.

Formula

$S = M \times L / T$

Where:

- S = Spreadability
- M = Weight applied on upper slide
- L = Length moved by slide
- T = Time taken

Importance

1. Better patient compliance
2. Ease of application
3. Uniform distribution on skin

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7.7 Extrudability Study

Objective

To determine force required to extrude gel from collapsible tube.

Procedure

1. Gel was filled into collapsible aluminum tube.
2. Pressure was applied on tube.
3. Amount of gel extruded was observed.

Observation

Good extrudability indicates:

1. Easy removal from tube
2. Better patient convenience

7.8 Washability Test

Objective

To determine ease of removal of gel from skin surface.

Procedure

1. Gel was applied on skin.
2. Water was used to wash formulation.
3. Ease of washing was observed visually.

Observation

An ideal gel should be easily washable without leaving residue.

VIII. RESULTS AND DISCUSSION

8.1 Overview

Results and discussion form an important part of pharmaceutical research work. This chapter presents the observations obtained during formulation and evaluation of herbal gel and discusses the significance of the results. Different formulations of herbal gel were prepared using varying concentrations of Carbopol 934 and herbal extracts. The prepared formulations were evaluated for various physicochemical and in-vitro parameters including appearance, pH, viscosity, spreadability, homogeneity, extrudability, drug content, and diffusion study.

The obtained results were compared to identify the optimized formulation with better therapeutic performance and stability.

8.2 Observation of Prepared Formulations

All prepared formulations were visually inspected for physical appearance, color, texture, homogeneity, and consistency.

Observation Table

Formulation	Color	Appearance	Consistency	Homogeneity
F1	Light green	Smooth	Moderate	Good
F2	Green	Smooth and glossy	Good	Excellent
F3	Dark green	Thick	High viscosity	Excellent

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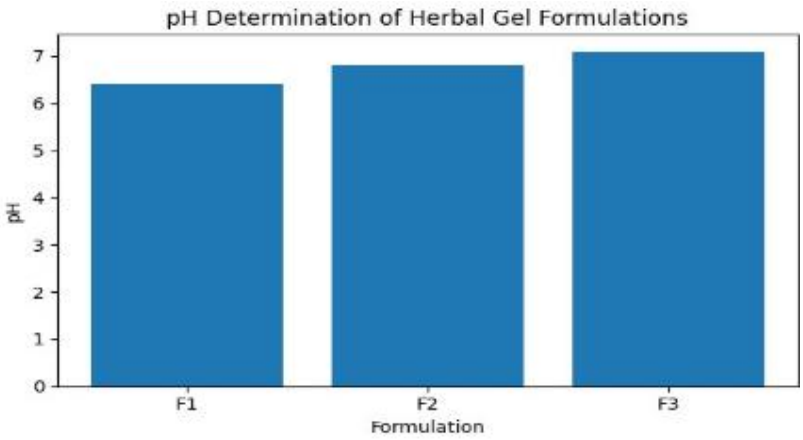
8.3 pH Determination

The pH of prepared formulations was measured using digital pH meter.

Result Table for pH

Formulation	pH
F1	6.4
F2	6.8
F3	7.1



Discussion

The pH values of all formulations were found to be within acceptable range for topical application. Formulation F2 showed pH nearest to skin pH, indicating better compatibility and reduced chances of skin irritation.

8.4 Viscosity Determination

The viscosity of herbal gel formulations was measured using Brookfield viscometer. Result Table for Viscosity

Formulation	**Viscosity (cps)**
F1	4200
F2	5100
F3	6800

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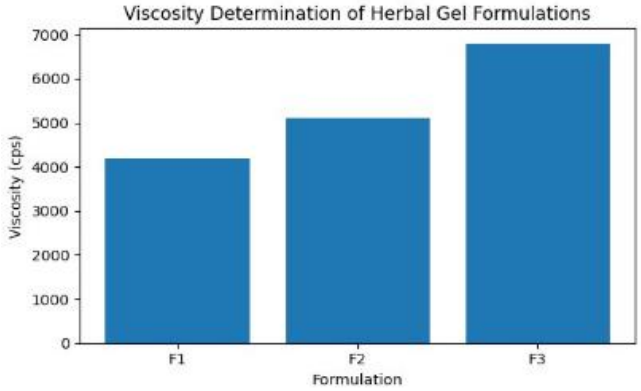


Discussion

Viscosity increased with increase in concentration of Carbopol 934. Formulation F3 exhibited highest viscosity due to higher polymer concentration. However, excessively high viscosity reduced spreadability. Formulation F2 showed optimum viscosity with better consistency and ease of application.

8.5 Spreadability Study

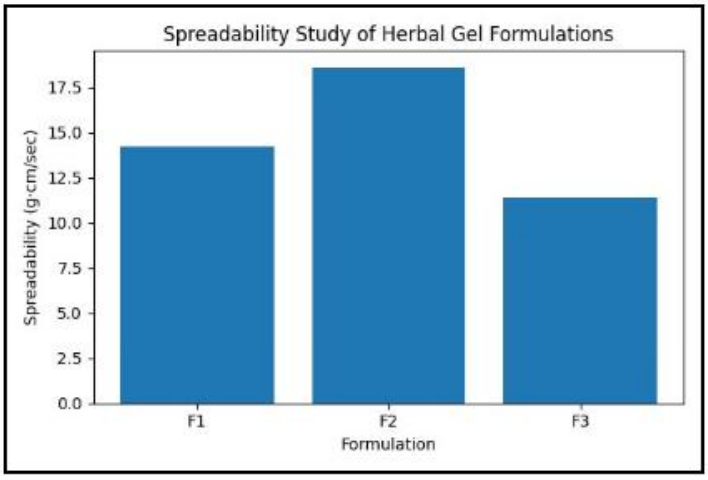
Spreadability of prepared formulations was evaluated by slide method.

Formula Used

$S = M \times L / T$

Result Table for Spreadability

Formulation	Spreadability (g·cm/sec)
F1	14.2
F2	18.6
F3	11.4



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Discussion

Formulation F2 exhibited maximum spreadability due to balanced viscosity and smooth texture. F3 showed lower spreadability because of higher viscosity. Good spreadability is important for easy application and uniform distribution on skin surface.

8.6 Extrudability Study

Extrudability was determined by measuring ease of gel extrusion from collapsible tube.

Observation Table

Formulation	Extrudability
F1	Good
F2	Excellent
F3	Moderate

Formulation F2 showed excellent extrudability due to optimum consistency and viscosity. F3 exhibited comparatively lower extrudability because of its thick nature.

8.7 Washability Test

Observation Table

Formulation	Washability
F1	Good
F2	Excellent
F3	Good

Discussion

All formulations were easily washable with water. Formulation F2 showed better washability because of its balanced gel consistency.

8.8 Drug Content Determination

Drug content analysis was performed using UV spectrophotometer.

Result Table for Drug Content

Formulation	Drug Content (%)
F1	91.4
F2	96.8
F3	94.2

Discussion

All formulations showed acceptable drug content uniformity. F2 demonstrated highest drug content, indicating proper incorporation and uniform distribution of herbal extracts.

8.9 In-Vitro Diffusion Study

In-vitro diffusion studies were performed using Franz diffusion cell.

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Time (hrs)	F1 (%)	F2 (%)	F3 (%)
1	18	22	15
2	31	39	28
3	46	57	41
4	59	71	52
5	69	84	63

8.10 Interpretation of Results

The study confirmed that concentration of polymer plays an important role in determining:

1. Viscosity
2. Spreadability
3. Drug release
4. Extrudability

Balanced polymer concentration produced better formulation characteristics and improved therapeutic performance.

The herbal ingredients demonstrated satisfactory compatibility with polymer and excipients.

IX. CONCLUSION

9.1 Summary of Research Work

The present research work focused on the formulation and in-vitro evaluation of herbal gel using selected herbal extracts such as Aloe vera, Neem, and Turmeric. Herbal gels are gaining importance in topical drug delivery because of their non-greasy nature, ease of application, improved patient compliance, and reduced side effects compared to synthetic formulations.

Different formulations were prepared using Carbopol 934 as a gelling agent and evaluated for various physicochemical and in-vitro parameters to obtain an optimized formulation with better stability and therapeutic effectiveness.

The study involved:

1. Selection of suitable herbal ingredients
2. Preparation of herbal extracts
3. Development of gel formulations
4. Evaluation of physicochemical properties
5. In-vitro diffusion studies
6. Stability studies of optimized formulation

Three formulations (F1, F2, and F3) were prepared by varying concentrations of Carbopol 934 and herbal extracts.

9.2 Major Findings of the Study

The prepared herbal gel formulations were successfully evaluated for:

1. Physical appearance
2. Homogeneity
3. pH
4. Spreadability
5. Viscosity
6. Extrudability
7. Drug content

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8. In-vitro diffusion
9. Stability

The results indicated that all formulations showed acceptable physicochemical characteristics. 9.3 Conclusion

The present study successfully formulated and evaluated herbal gel using Aloe vera, Neem, and Turmeric extracts with Carbopol 934 as a gelling agent.

The prepared formulations exhibited satisfactory physicochemical characteristics, good spreadability, acceptable viscosity, skin-compatible pH, excellent homogeneity, and enhanced in-vitro drug release.

Among all formulations, F2 was found to be the optimized formulation due to its superior evaluation parameters and stability profile.

The study concluded that herbal gel can serve as an effective, safe, stable, and economical topical drug delivery system with significant therapeutic potential for skin-related disorders and cosmetic applications.

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