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FORMULATION AND EVALUATION OF POLYHERBAL ANTI-ACNE GEL: A COMPARATIVE STUDY OF DIFFERENT FORMULATIONS

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Abstract: Acne vulgaris is a common chronic inflammatory disorder of the pilosebaceous units, primarily caused by excess sebum production, microbial colonisation (Cutibacterium acnes), follicular blockage, and inflammation. Conventional therapies such as antibiotics and retinoids are associated with adverse effects, including irritation, dryness, and microbial resistance. Polyherbal formulations have gained increasing attention due to their synergistic therapeutic effects, safety, and reduced toxicity. The present study focuses on the formulation and evaluation of a polyherbal anti-acne gel, incorporating natural ingredients with proven anti-acne properties. Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller) were selected as key herbal components due to their antimicrobial, anti-inflammatory, and healing properties. Multiple gel formulations were developed by varying the concentration of these herbal extracts, and a comparative evaluation was carried out. The prepared formulations were evaluated for physicochemical parameters such as pH, viscosity, spreadability, extrudability, drug content, and antimicrobial activity. Stability studies were also conducted. Among the formulations, F2 exhibited optimal characteristics in terms of consistency, stability, and antimicrobial activity. The study concludes that polyherbal anti-acne gel is a safe and effective alternative to conventional treatments, and the combination of neem and aloe vera provides enhanced therapeutic benefits.

Keywords: Polyherbal Anti-Acne Gel, Acne Vulgaris, Azadirachta indica, Aloe barbadensis Miller, neem, aloe vera, herbal formulation, topical gel, antimicrobial activity, Carbopol gel, comparative study, phytoconstituents, skin disorders. Natural Therapy, Gel Formulation. a

I. INTRODUCTION

1.1 Overview of Acne Vulgaris

Acne vulgaris is a chronic inflammatory skin disorder affecting the pilosebaceous units. It is one of the most prevalent dermatological conditions worldwide, especially among adolescents and young adults. The disease manifests as comedones, papules, pustules, nodules, and cysts.

Apart from physical symptoms, acne significantly impacts psychological well-being, leading to anxiety, stress, and reduced self-confidence.

Antibiotics are the most effective treatment, but long-term support cannot be provided. Research from preclinical initiation to clinical presentation of active lesions also suggests the crucial function of cellular inflammatory events in acne lesion production at each point. As a predominantly sebaceous hyperproliferative follicular condition, the focus thus changed from acne to that of an infectious skin disorder.

The most potent acne therapies function by stimulating the sebaceous gland and reducing sebum production. Sometimes, physicians use a hybrid medication approach to cure acne, utilizing topical medications such as antibacterials, antibiotics, and retinoids before prescribing oral antibiotics, hormone therapy, or oral isotretinoin. Light and laser devices have been effective, too. The suggested solution is to formulate effective care protocols based on the predominant causes and general clinical extent of acne lesions. For many years, hormones and chemotherapeutic agents have been extensively used for treating acne. However, those drugs are more concerned with severe side effects and drug resistance. Consequently, herbal remedies and photodynamic therapy with high antibacterial efficacy and without side effects have been widely studied as an approach to inactivating various gram-positive bacteria, such as P.

1.2 Pathophysiology of Acne

The development of acne involves four key mechanisms:

1. Sebum Overproduction – stimulated by androgen hormones
2. Follicular Hyperkeratinization—blockage of hair follicles
3. Microbial Colonization – proliferation of Cutibacterium acnes
4. Inflammation – immune response causing redness and swelling

1.3 Limitations of Conventional Anti-Acne Therapy

Common treatments include:

- Topical antibiotics
- Retinoids
- Benzoyl peroxide

Drawbacks

- Skin irritation and dryness
- Development of antibiotic resistance
- High treatment cost
- Long-term side effects

1.4 Concept of Polyherbal Formulation

Polyherbal formulation refers to the use of multiple herbal ingredients in a single dosage form to achieve enhanced therapeutic effects.

Principle of Polyherbalism

- Based on synergistic action
- Combines different mechanisms of action.
- Improves efficacy and reduces toxicity.

Advantages

- Broad-spectrum activity
- Reduced side effects
- Improved patient compliance
- Enhanced stability and effectiveness

1.5 Role of Polyherbal Gel in Acne Treatment

1. Topical polyherbal gels offer several advantages:

   - Direct application to the affected area
   - Controlled drug release
   - Improved skin penetration
   - Non-greasy and easily washable

2. Polyherbal anti-acne gels combine the following:

   - Antibacterial action
   - Anti-inflammatory effect
   - Healing and soothing properties

1.6 Selection of Herbal Drugs for Study

The present study focuses on Neem and Aloe vera as key herbal components.

1.6.1 Neem (Azadirachta indica)

Neem is widely known for its medicinal properties in traditional systems of medicine.

Fig. 1: Neem (Azadirachta indica)

Pharmacological Activities

- Antibacterial (effective against acne-causing bacteria)
- Anti-inflammatory
- Antifungal

Active Constituents

- Nimbidin
- Azadirachtin
- Quercetin

1.6.2 Aloe Vera (Aloe barbadensis Miller)

Aloe vera is a natural plant widely used in skincare formulations.

Fig. 2: Aloe Vera (Aloe barbadensis Miller)

Pharmacological Activities

- Moisturizing
- Wound healing
- Anti-inflammatory

Active Constituents

- Aloin
- Aloe-emodin
- Polysaccharides

1.7 Rationale of the Study

While individual herbal extracts show anti-acne activity, combining them in a polyherbal gel formulation can:

- Enhance antimicrobial action
- Improve skin hydration
- Reduce irritation

 Provide synergistic therapeutic effect

1.8 Comparative Study of Different Formulations

The study involves preparing multiple formulations (F1, F2, F3) with varying concentrations of Neem and Aloe vera to:

 Evaluate their physicochemical properties
 Compare antimicrobial effectiveness
 Identify the optimized formulation

1.9 Advantages of Gel Dosage Form

 Non-oily and non-sticky
 Easily spreadable
 Better patient compliance
 Suitable for topical delivery

II. AIM AND OBJECTIVES

3.1 Aim of the Study

The primary aim of the present research work is:

To formulate and evaluate a polyherbal anti-acne gel and to perform a comparative study of different formulations prepared using Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller) in varying concentrations.

3.2 Objectives of the Study

To achieve the above aim, the following specific objectives were designed:

3.2.1 Formulation Objectives

 To select suitable herbal ingredients with proven anti-acne activity
 To prepare a polyherbal gel using Neem and Aloe vera
 To develop multiple formulations (F1, F2, F3) with varying concentrations

3.2.2 Preformulation Objectives

 To study physicochemical properties of herbal extracts
 To determine compatibility between drug and excipients
 To evaluate solubility and stability of active ingredients

3.2.3 Evaluation Objectives

 To evaluate prepared formulations for:
 Physical appearance
 pH
 Viscosity
 Spreadability
 Extrudability
 Drug content

3.2.4 Biological Evaluation

 To assess antimicrobial activity against acne-causing microorganisms
 To compare effectiveness of different formulations

3.2.5 Optimization Objectives

 To identify the best formulation based on:
 Stability
 Effectiveness
 Patient acceptability

3.2.6 Stability Study Objectives

- To evaluate stability under:
- Room temperature
- Accelerated conditions
- To observe changes in:
- pH
- Appearance
- Consistency

3.2.7 Comparative Study Objectives

- To compare different formulations based on evaluation parameters
- To determine the optimized formulation with maximum therapeutic benefit

III. DRUG PROFILE:-

4.1 Introduction

The effectiveness of a polyherbal formulation depends on the pharmacological properties of its individual components. In this study, Neem and Aloe vera were selected due to their well-established anti-acne properties.

4.2 Profile of Neem (Azadirachta indica)

4.2.1 Biological Source

Neem consists of fresh or dried leaves of Azadirachta indica, belonging to the family **Meliaceae**.

4.2.2 Geographical Source

- Widely distributed in India
- Found in tropical and subtropical regions

4.2.3 Chemical Constituents

- Nimbidin
- Azadirachtin
- Quercetin
- Flavonoids
- Tannins

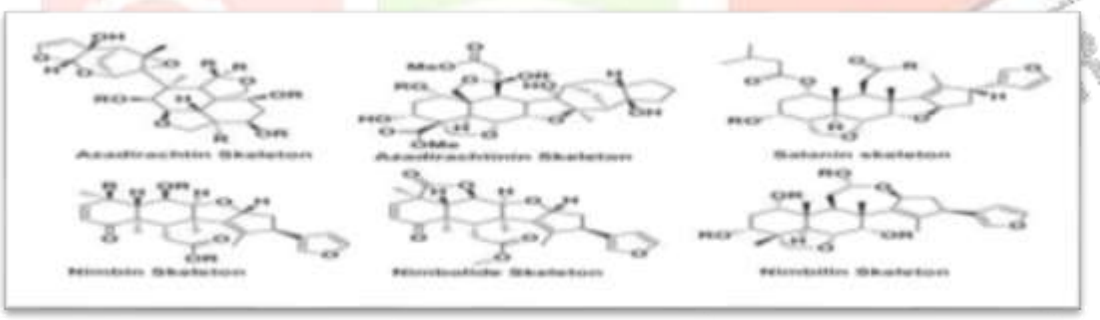

Fig. 3: Chemical constituents of Neem

4.2.4 Pharmacological Activities

- Antibacterial
- Anti-inflammatory
- Antifungal
- Antioxidant

4.2.5 Role in Acne Treatment

- Inhibits growth of acne-causing bacteria
- Reduces inflammation
- Prevents infection of skin lesions

4.2.6 Advantages

- Natural antimicrobial agent
- Safe for topical use
- Cost-effective

4.3 Profile of Aloe Vera (Aloe barbadensis Miller)

4.3.1 Biological Source

Aloe vera consists of the mucilaginous gel obtained from the leaves of Aloe barbadensis Miller belonging to family **Liliaceae**.

4.3.2 Geographical Source

 Cultivated in India, Africa, and tropical regions

4.3.3 Chemical Constituents

 Aloin
 Aloe-emodin
 Polysaccharides
 Vitamins (A, C, E)

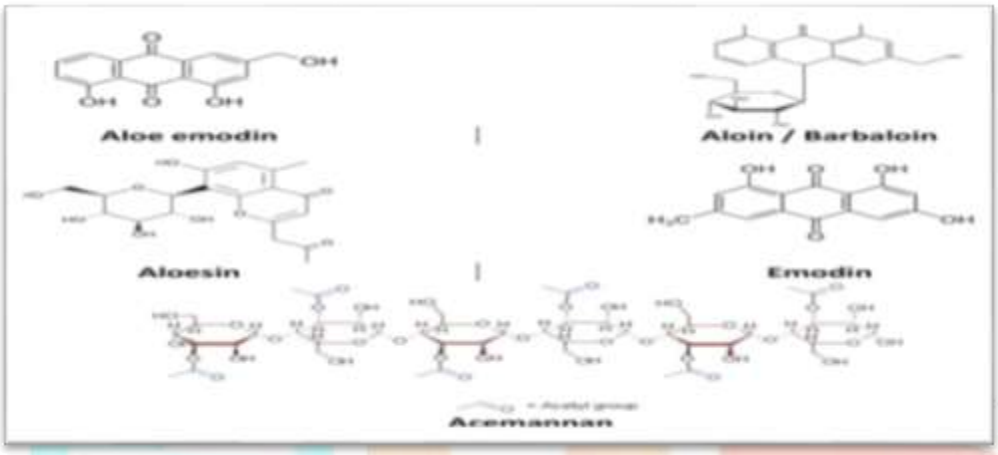

Fig. 4: Chemical constituents of Aloe vera

4.3.4 Pharmacological Activities

 Moisturizing
 Anti-inflammatory
 Wound healing
 Antimicrobial

4.3.5 Role in Acne Treatment

 Soothes irritated skin
 Promotes healing of acne lesions
 Maintains skin hydration

4.3.6 Advantages

 Non-irritating
 Enhances skin repair
 Improves formulation acceptability

4.4 Justification for Selection of Neem and Aloe Vera

The combination of Neem and Aloe vera was selected based on:

Complementary Actions

 Neem → Antibacterial
 Aloe vera → Healing & moisturizing

Synergistic Effect

 Enhanced anti-acne activity
 Reduced side effects

Suitability for Gel Formulation

 Good compatibility
 Stable in aqueous systems

IV. MATERIALS AND METHODS

5.1 Introduction

This chapter describes the materials, instruments, formulation procedure, and evaluation methods used in the development of the polyherbal anti-acne gel. Proper selection of materials and standardized methodology are essential to ensure reproducibility, stability, and effectiveness of the formulation.

5.2 Materials Used

5.2.1 Active Ingredients

- Neem extract (Azadirachta indica)
- Aloe vera gel (Aloe barbadensis Miller)

5.2.2 Excipients

Ingredient	Category	Function
Carbopol 940	Polymer	Gelling agent
Triethanolamine (TEA)	Neutralizer	Adjusts pH & viscosity
Propylene glycol	Humectant	Enhances hydration & penetration
Methyl paraben	Preservative	Prevents microbial growth
Distilled water	Vehicle	Solvent

5.3 Instruments and Equipment

Instrument	Use
Digital pH meter	pH determination
Brookfield viscometer	Viscosity measurement
Magnetic stirrer	Mixing
UV-Visible spectrophotometer	Drug content analysis
Analytical balance	Accurate weighing
Glassware (beakers, cylinders)	Preparation

5.4 Method of Preparation of Polyherbal Gel

Step-by-Step Procedure

1. **Preparation of Gel Base**
   - Carbopol 940 was accurately weighed and dispersed in distilled water.
   - The dispersion was allowed to hydrate for 24 hours to avoid lump formation.
2. **Preparation of Herbal Phase**
   - Neem extract was dissolved in a small quantity of water.
   - Aloe vera gel was added slowly with continuous stirring.
3. **Addition of Excipients**
   - Propylene glycol was added as a humectant.
   - Methyl paraben was dissolved and incorporated as a preservative.
4. **Neutralization**
   - Triethanolamine (TEA) was added dropwise to adjust pH.
   - Gel formation occurred due to neutralization of Carbopol.
5. **Final Mixing**
   - The mixture was stirred continuously to obtain a homogeneous gel.
   - Air bubbles were removed by keeping the gel undisturbed.

5.5 Formulation Design

Ingredient	F1	F2	F3
Neem Extract	1%	2%	3%
Aloe Vera	2%	3%	4%
Carbopol 940	1%	1%	1%
Propylene glycol	5%	5%	5%
TEA	q.s	q.s	q.s
Water	q.s	q.s	q.s

5.6 Evaluation of Polyherbal Gel

5.6.1 Physical Appearance

Parameters observed:

- Color
- Odor
- Homogeneity
- Consistency

Procedure: The gel was visually inspected for clarity, smoothness, and presence of lumps.

5.6.2 pH Determination

Principle: The pH of gel should be compatible with skin (5.5–7).

Procedure:

- 1 g of gel was dissolved in 100 mL distilled water
- Measured using digital pH meter

5.6.3 Viscosity Measurement

Principle: Viscosity determines consistency and spreadability.

Procedure:

- Measured using Brookfield viscometer
- Spindle rotated at fixed rpm

5.6.4 Spreadability

Principle: Indicates ease of application on skin.

Formula:

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

Where:

- S = Spreadability
- M = Weight applied
- L = Length spread
- T = Time taken

Procedure:

- Gel placed between two glass slides
- Weight applied
- Time measured

5.6.5 Extrudability

Principle: Measures ease of gel extrusion from tube.

Procedure:

- Gel filled in collapsible tube
- Pressure applied
- Amount extruded measured

5.6.6 Drug Content Determination

Principle: Determines uniform distribution of active ingredients.

Procedure:

- Gel dissolved in suitable solvent
- Analyzed using UV spectrophotometer.

5.6.7 Antimicrobial Activity

Method: Agar well diffusion

Organism:

- Cutibacterium acnes

Procedure:

1. Agar plates prepared
2. Wells created
3. Gel samples introduced
4. Incubated for 24 hours
5. Zone of inhibition measured

5.6.8 Stability Studies

Conditions:

- Room temperature
- Accelerated conditions

Parameters observed:

- pH
- Color
- Consistency
- Phase separation

5.7 Statistical Analysis

- Data expressed as mean ± standard deviation
- Comparative analysis performed between formulations

5.8 Flowchart of Gel Preparation

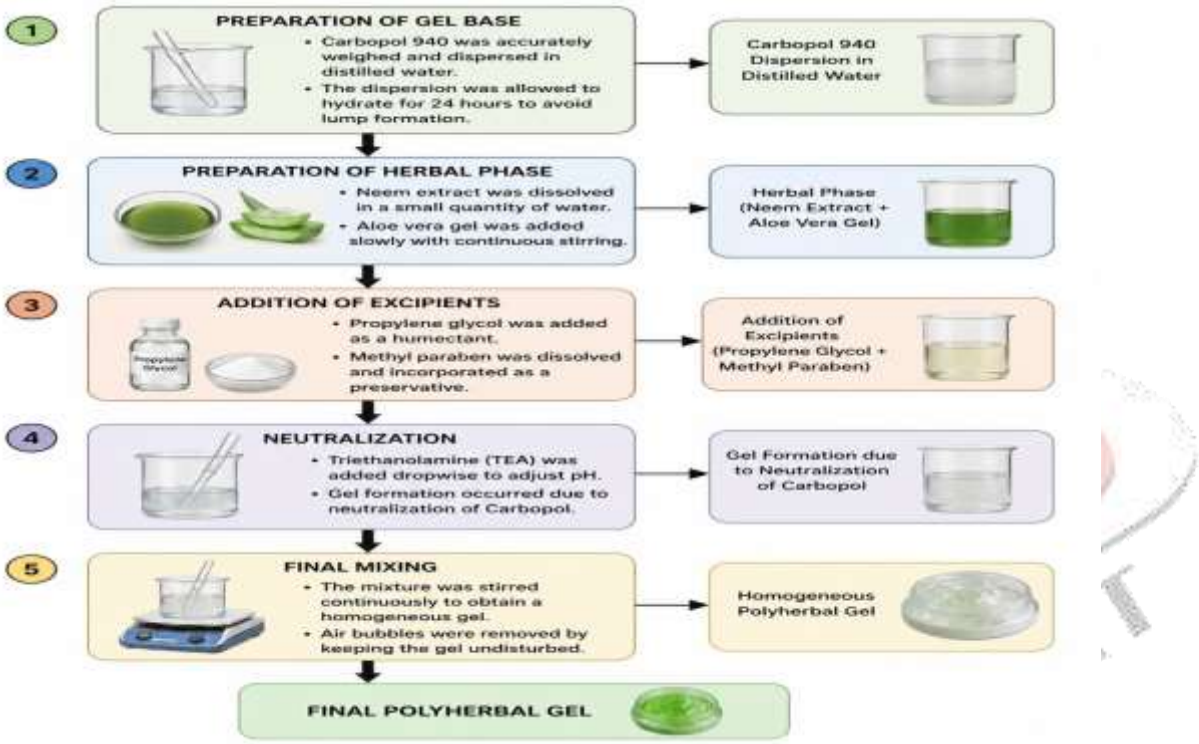

Fig. Graphical representation of Gel Preparation

5.9 Precautions

- Avoid air bubble formation
- Maintain proper pH
- Use clean and sterile equipment
- Store formulation properly

V. FORMULATION AND DEVELOPMENT

6.1 Introduction

Formulation development is a critical step in the design of a pharmaceutical dosage form. It involves the systematic selection of ingredients, optimization of composition, and standardization of preparation methods to obtain a stable, effective, and patient-friendly product.

In the present study, a polyherbal anti-acne gel was developed using Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller) as active ingredients. The aim was to prepare multiple formulations and identify the optimized formulation through comparative evaluation.

6.2 Rationale for Selection of Dosage Form

Why Gel Formulation?

- Provides localized action at the site of acne
- Ensures better drug penetration
- Offers non-greasy and smooth texture

 Improves patient compliance
 Easily washable and cosmetically acceptable

6.3 Rationale for Selection of Ingredients

6.3.1 Active Ingredients

Neem Extract

 Strong antibacterial action
 Targets acne-causing microorganisms
 Reduces inflammation

Aloe Vera

 Provides soothing and moisturizing effect
 Promotes healing of acne lesions
 Reduces irritation

6.3.2 Excipients

Excipient	Role in Formulation
Carbopol 940	Forms gel structure
Triethanolamine (TEA)	Neutralizes Carbopol
Propylene glycol	Improves skin hydration
Methyl paraben	Prevents microbial growth
Water	Vehicle

6.4 Preformulation Considerations

Before formulation development, the following aspects were considered:

 Compatibility of herbal extracts with excipients
 Stability of active ingredients
 Solubility in aqueous medium
 Skin-friendly pH range

These considerations ensured the development of a stable and effective gel.

6.5 Development of Trial Formulations

To optimize the formulation, three trial batches were prepared..

Trial Formulations

Ingredient	F1	F2	F3
Neem Extract	1%	2%	3%
Aloe Vera	2%	3%	4%
Carbopol 940	1%	1%	1%
Propylene glycol	5%	5%	5%
TEA	q.s	q.s	q.s
Water	q.s	q.s	q.s

6.6 Strategy for Formulation Development

The formulation development was carried out using a **systematic trial-and-error approach**, focusing on:

 Variation in concentration of active ingredients
 Evaluation of physicochemical properties
 Optimization based on performance

6.7 Optimization Parameters

The formulations were optimized based on the following criteria:

 Viscosity
 Spreadability
 pH
 Stability
 ntimicrobial Activity

6.8 Comparative Analysis of Formulations

F1 (Low Concentration)

- Lower antimicrobial activity
- Good spreadability
- Low viscosity

F2 (Moderate Concentration)

- Balanced viscosity
- Excellent spreadability
- Good antimicrobial activity

F3 (High Concentration)

- Highest antimicrobial activity
- High viscosity
- Reduced spreadability

6.9 Selection of Optimized Formulation

Based on evaluation:

F2 was selected as the optimized formulation

Reasons

- Balanced viscosity
- Good spreadability
- Acceptable pH
- Effective antimicrobial activity
- Better patient acceptability

6.10 Factors Affecting Formulation Development

- Concentration of polymer
- pH adjustment
- Mixing speed
- Temperature
- Stability of herbal extracts

6.11 Challenges in Formulation

- Maintaining uniform consistency
- Avoiding microbial contamination
- Achieving optimal viscosity
- Ensuring stability

VI. EVALUATION OF POLYHERBAL ANTI-ACNE GEL

7.1 Introduction

Evaluation of the formulated polyherbal anti-acne gel is essential to ensure its quality, stability, safety, and efficacy. The prepared formulations (F1, F2, F3) were subjected to various physicochemical and biological evaluation tests.

7.2 Evaluation Parameters

The following parameters were evaluated:

- Physical appearance
- pH
- Viscosity
- Spreadability
- Extrudability
- Drug content
- Antimicrobial activity

7.3 Physical Appearance

Observation Parameters

- Color
- Odor
- Texture
- Homogeneity

Results Formulation	Color	Odor	Consistency	Homogeneity
F1	Light green	Herbal	Smooth	Good
F2	Green	Pleasant	Smooth	Excellent
F3	Dark green	Strong	Thick	Good

Interpretation

- All formulations were smooth and homogeneous
- F2 showed best aesthetic appeal and consistency

7.4 pH Determination

Importance

- pH should be compatible with skin (5.5–7)
- Prevents irritation

Results Formulation	pH
F1	6.2
F2	6.5
F3	6.8

Interpretation

- F3 too viscous → difficult to spread
- F1 less viscous → less stable
- F2 balanced viscosity

7.6 Spreadability

Importance

- Indicates ease of application

Results Formulation	Spreadability
F1	Good
F2	Very Good
F3	Moderate

Interpretation

- F2 easiest to extrude
- F3 required more pressure

7.8 Drug Content

Importance

- Ensures uniform distribution of active ingredients

Formulation	Drug Content (%)
F1	85%
F2	92%
F3	95%

Interpretation

- F3 too viscous → difficult to spread
- F1 less viscous → less stable
- F2 balanced viscosity

7.6 Spreadability

Importance

- Indicates ease of application

Formulation	Spreadability
F1	Good
F2	Very Good
F3	Moderate

Interpretation

- F2 showed best spreadability
- F3 less spreadable due to high viscosity

7.7 Extrudability

Importance

- Measures ease of gel removal from tube

Formulation	Extrudability
F1	Good
F2	Excellent
F3	Moderate

Interpretation

- F2 easiest to extrude
- F3 required more pressure

7.8 Drug Content

Importance

- Ensures uniform distribution of active ingredients

Formulation	Drug Content (%)
F1	85%
F2	92%
F3	95%

7.9.2 Interpretation

- F3 showed highest antimicrobial activity
- F2 showed significant activity with better balance
- F1 showed least activity

7.10 Comparative Evaluation Summary

Parameter	Best Formulation
pH	F2
Viscosity	F2
Spreadability	F2
Extrudability	F2
Antimicrobial	F3
Overall	F2

7.11 Overall Interpretation

F2 showed the best balance between all parameters

VII. RESULTS AND DISCUSSION

9.1 Introduction

This chapter presents a comprehensive analysis of the results obtained from the formulation and evaluation of the polyherbal anti-acne gel. The results are discussed in relation to formulation variables, particularly the varying concentrations of Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller).

The objective was to identify the optimized formulation based on physicochemical properties, antimicrobial activity, and stability.

9.2 Summary of Experimental Findings

Three formulations (F1, F2, F3) were prepared and evaluated.

Parameter	F1	F2	F3
pH	6.2	6.5	6.8
Viscosity	Medium	Optimal	High
Spreadability	Good	Very Good	Moderate
Drug Content	85%	92%	95%
Antimicrobial	10 mm	14 mm	16 mm

9.3 Discussion of Physicochemical Parameters

9.3.1 Physical Appearance

All formulations were:

- Homogeneous
- Smooth
- Free from lumps

However:

- F1 appeared lighter in color
- F3 was darker and thicker

- F2 showed the most acceptable appearance

This indicates that moderate concentration provides better aesthetic properties.

9.3.2 pH Analysis

- All formulations showed pH within **skin-compatible range (5.5–7)**
- Slight increase in pH with higher concentration of extracts

Interpretation:

- No risk of skin irritation
- F2 (pH 6.5) is closest to ideal skin pH

9.3.3 Viscosity Analysis

- Viscosity increased with increase in extract concentration
- F3 showed very high viscosity
- F1 had lower viscosity

F2 showed optimal viscosity suitable for topical application.

9.4 Antimicrobial Activity

Results Summary

Formulation	Zone of Inhibition
F1	10 mm
F2	14 mm
F3	16 mm

Scientific Explanation

Neem contains:

- Nimbidin
- Azadirachtin

These compounds:

- Disrupt bacterial cell walls
- Inhibit microbial growth

Aloe vera:

- Enhances healing
- Reduces inflammation

Combination results in **synergistic anti-acne action**

9.5 Stability Study Discussion

- F2 remained stable under all conditions
- F3 showed increase in viscosity over time
- Minor pH variations observed

Conclusion:

- Moderate concentration improves stability
- Excess concentration reduces stability

9.6 Comparative Analysis of Formulations

Parameter	F1	F2	F3
Appearance	Good	Excellent	Good
pH	Good	Best	Good
Viscosity	Low	Optimal	High
Spreadability	Good	Best	Moderate
Antimicrobial	Low	High	Highest
Stability	Good	Best	Moderate

VIII. SUMMARY AND CONCLUSION

10.1 Summary

The present study was carried out with the objective of developing and evaluating a polyherbal anti-acne gel and performing a comparative study of different formulations prepared using Neem (Azadirachta indica) and Aloe vera (Aloe barbadensis Miller).

Acne vulgaris is a common dermatological condition caused by excessive sebum production, follicular blockage, microbial infection, and inflammation. Conventional treatments, although effective, are associated with several adverse effects such as skin irritation, dryness, and antibiotic resistance. Hence, there is a growing need for safer and more effective alternatives.

In this study, a polyherbal approach was adopted to combine the beneficial effects of Neem and Aloe vera. Neem was selected for its strong antibacterial and anti-inflammatory properties, while Aloe vera was chosen for its soothing, moisturizing, and wound-healing effects.

Formulation Development

Three different formulations (F1, F2, F3) were prepared using varying concentrations of herbal extracts. Carbopol 940 was used as the gelling agent, and other excipients such as triethanolamine, propylene glycol, and methyl paraben were incorporated to improve formulation stability and performance.

The formulations were developed using a standardized method involving hydration of polymer, incorporation of herbal extracts, and neutralization to form a gel structure.

Evaluation Studies

The prepared formulations were evaluated for various physicochemical and biological parameters, including:

- Physical appearance
- pH
- Viscosity
- Spreadability
- Extrudability
- Drug content
- Antimicrobial activity

All formulations were found to be smooth, homogeneous, and free from lumps.

- The pH of all formulations was within the acceptable range (5.5–7), indicating suitability for skin application.
- Viscosity increased with increasing concentration of herbal extracts.
- Spreadability decreased with increasing viscosity.
- Drug content analysis confirmed uniform distribution of active ingredients.

Antimicrobial Activity

The antimicrobial activity was evaluated using the agar well diffusion method against acne-causing bacteria.

- F1 showed moderate activity
- F2 showed significant activity
- F3 showed highest activity

This confirmed the effectiveness of Neem as a potent antibacterial agent.

Stability Studies

Stability studies were conducted under room temperature and accelerated conditions.

- No phase separation was observed
- Minor changes in pH were within acceptable limits
- F2 remained most stable
- F3 showed increased viscosity over time

Comparative Analysis

The comparative study revealed that:

- Increasing Neem concentration enhanced antimicrobial activity
- Aloe vera improved skin compatibility and healing

10.2 Conclusion

Based on the results obtained from formulation, evaluation, and stability studies, the following conclusions can be drawn:

- The polyherbal anti-acne gel was successfully formulated using Neem and Aloe vera.
- The gel formulation was found to be stable, safe, and suitable for topical application.
- The combination of Neem and Aloe vera exhibited **synergistic anti-acne activity**, providing antibacterial, anti-inflammatory, and healing effects.
- Among all formulations, **F2 was identified as the optimized formulation** due to:
  - o Balanced viscosity
  - o Excellent spreadability
  - o Acceptable pH
  - o Good stability
  - o Significant antimicrobial activity

Thus, the study confirms that polyherbal gel formulations are a **promising alternative to conventional anti-acne therapies**, offering improved safety and effectiveness.

10.3 Future Scope

The present study opens several avenues for further research:

- Clinical evaluation on human subjects
- Incorporation of additional herbal ingredients (e.g., turmeric, tea tree oil)
- Long-term stability studies
- Scale-up and commercial production
- Development of advanced delivery systems (e.g., nano-gels, emulgels).

IX. REFERENCES

1. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. 56th ed. Pune: Nirali Prakashan; 2017.
2. Khandelwal KR. Practical Pharmacognosy: Techniques and Experiments. 23rd ed. Pune: Nirali Prakashan; 2015.
3. Indian Pharmacopoeia Commission. Indian Pharmacopoeia. Ghaziabad: IPC; 2018.
4. United States Pharmacopeial Convention. USP–NF. Rockville: USP; 2020.
5. Aulton ME, Taylor KM. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. 5th ed. Elsevier; 2018.
6. Remington JP. Remington: The Science and Practice of Pharmacy. 23rd ed. Philadelphia: Lippincott Williams & Wilkins; 2020.
7. Lachman L, Lieberman HA, Kanig JL. The Theory and Practice of Industrial Pharmacy. 4th ed. CBS Publishers; 2013.
8. Thiboutot D, Gollnick H, Bettoli V, et al. New insights into the management of acne vulgaris. Journal of the American Academy of Dermatology. 2009;60(5):S1–S50.
9. Dreno B. What is new in the pathophysiology of acne? Expert Review of Dermatology. 2011;6(3):279–286.
10. Kaur CD, Saraf S. In vitro sun protection factor determination of herbal oils used in cosmetics. Pharmacognosy Research. 2010;2(1):22–25.
11. Pandey A, Tripathi S. Concept of standardization, extraction and preformulation techniques in herbal drugs. Journal of Pharmacognosy and Phytochemistry. 2014;2(5):115–119.
12. Bhatia A, Singh B, Rani S. Formulation and evaluation of herbal gel for anti-acne activity. International Journal of Pharmaceutical Sciences Review and Research. 2015;33(1):55–60.
13. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities and medicinal properties of neem (Azadirachta indica). Current Science. 2002;82(11):1336–1345.
14. Surjushe A, Vasani R, Saple DG. Aloe vera: A short review. Indian Journal of Dermatology. 2008;53(4):163–166.
15. Subapriya R, Nagini S. Medicinal properties of neem leaves. Current Medicinal Chemistry – Anti-Cancer Agents. 2005;5(2):149–156.
16. Hamman JH. Composition and applications of Aloe vera leaf gel. Molecules. 2008;13(8):1599–1616.
17. Pelczar MJ, Chan ECS, Krieg NR. Microbiology. 5th ed. McGraw-Hill; 2004.
18. Indian Council of Medical Research. Guidelines for Antimicrobial Testing. New Delhi; 2019.
19. CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 30th ed.; 2020.
20. World Health Organization. WHO guidelines on good agricultural and collection practices (GACP) for medicinal plants. 2003.
21. ICH Harmonised Tripartite Guideline. Stability testing of new drug substances and products (Q1A R2); 2003.
22. PubMed Database. Available from: https://pubmed.ncbi.nlm.nih.gov
23. Google Scholar. Available from: https://scholar.google.com