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Review on Formulation and Evaluation of Herbal Emulgel Containing Tea Tree Oil and Aloe Vera Gel for Anti-Acne Therapy

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Abstract : *The present review focuses on the formulation and evaluation of a herbal emulgel incorporating tea tree oil and aloe vera gel for potential anti-acne therapy. Emulgel, a combination of emulsion and gel systems, offers advantages such as improved spreadability, enhanced patient acceptability, non-greasy characteristics, and the ability to incorporate both oil-soluble and water-soluble herbal ingredients. The review discusses the pharmacological properties of selected herbal constituents, formulation approaches, suitable excipients, and important evaluation parameters, including physical appearance, homogeneity, pH, viscosity, spreadability, extrudability, drug content, stability, and in-vitro antimicrobial activity. The combined use of tea tree oil and aloe vera may provide complementary benefits by addressing microbial growth and skin inflammation while maintaining skin hydration. This herbal emulgel represents a promising approach for developing a topical formulation for acne management. However, further experimental studies, safety assessments, and clinical investigations are necessary to establish its efficacy, stability, and therapeutic potential.*

Keywords: Acne vulgaris, Herbal emulgel, Tea tree oil, Melaleuca alternifolia, Aloe vera, Aloe barbadensis Miller, Anti-acne activity, Topical drug delivery, Antimicrobial activity.

1. INTRODUCTION

Acne vulgaris is a common chronic inflammatory disorder of the pilosebaceous unit, mainly affecting the face, chest, shoulders, and back [16]. It is frequently observed during adolescence and may continue into adulthood. The major factors responsible for acne development include excessive sebum secretion, abnormal follicular keratinization, microbial proliferation, particularly Cutibacterium acnes, and inflammatory responses within the skin. Acne may cause physical discomfort, scarring, and psychological distress, affecting an individual's confidence and quality of life [17].

Conventional treatments for acne include topical antibiotics, retinoids, benzoyl peroxide, and other pharmaceutical agents. Although these treatments are effective in many cases, they may produce unwanted effects such as dryness, irritation, redness, peeling, and increased skin sensitivity. Long-term or inappropriate antibiotic use may also contribute to antimicrobial resistance. Therefore, interest in herbal-based topical formulations has increased as researchers explore alternative approaches to acne management [6,24].

Herbal medicines contain several naturally occurring phytoconstituents that may possess antimicrobial, antioxidant, anti-inflammatory, and skin-protective properties. Among these, tea tree oil and aloe vera have attracted attention because of their complementary properties [22].

Tea tree oil, obtained from the leaves of Melaleuca alternifolia, is an essential oil containing terpinen-4-ol as one of its major active constituents. It is reported to possess antimicrobial and anti-inflammatory activities. These properties make it a potential herbal ingredient for topical acne preparations [7].

Aloe vera, scientifically known as Aloe barbadensis Miller, is a medicinal plant widely used in skincare products. Its gel contains polysaccharides, vitamins, enzymes, and other bioactive constituents. It is associated with moisturizing,

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soothing, wound-healing, and anti-inflammatory properties. Its incorporation into topical preparations may help maintain skin hydration and improve formulation acceptability [23].

An emulgel is a topical drug delivery system that combines the characteristics of an emulsion and a gel. It provides an effective platform for incorporating both oil-soluble and water-soluble ingredients. Tea tree oil can be incorporated into the oil phase, while aloe vera gel can be included in the aqueous or gel phase, depending on formulation compatibility [15,20].

The proposed herbal emulgel containing tea tree oil and aloe vera gel aims to combine antimicrobial and soothing properties in a convenient topical dosage form. This review discusses the pharmaceutical significance, formulation development, evaluation parameters, and potential applications of this herbal emulgel in acne management [1,2].

II. PATHOPHYSIOLOGY OF ACNE VULGARIS :

Acne vulgaris is a multifactorial inflammatory skin condition involving the pilosebaceous unit. Its development is associated with four major pathological mechanisms [16,17,22].

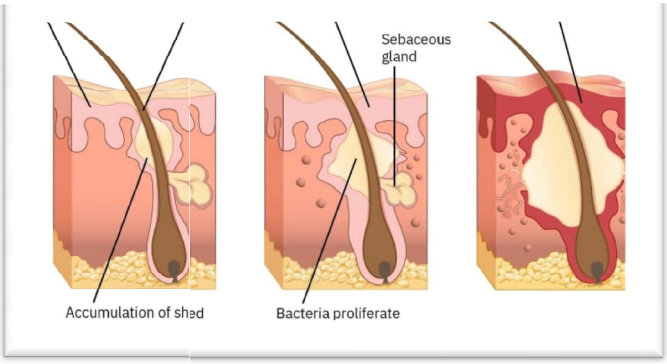

Fig.1. Pathology of Acne Vulgaris.

1.1 Increased Sebum Production

Sebaceous glands produce sebum, an oily substance that protects and lubricates the skin [17]. Increased androgen activity can stimulate sebaceous glands, resulting in excessive sebum production. Accumulation of sebum within hair follicles contributes to acne development [23].

1.2 Follicular Hyperkeratinization

Abnormal multiplication and shedding of follicular epithelial cells can cause blockage of the hair follicle. This results in the formation of microcomedones, which may develop into open or closed comedones [23].

1.3 Microbial Proliferation

Cutibacterium acnes is a normal component of the skin microbiome. However, changes in the follicular environment can promote its involvement in acne-associated inflammation [22].

1.4 Inflammation

Microbial products and altered follicular lipids can activate immune responses and stimulate the release of inflammatory mediators. This may result in redness, swelling, papules and pustules [16].

These four mechanisms interact with each other and contribute to the development and progression of acne lesions [22].

III. DIFFERENT FORMULATIONS USED FOR THE TREATMENT OF ACNE VULGARIS:

Acne vulgaris is a common inflammatory skin disorder involving hair follicles and sebaceous glands. Different pharmaceutical formulations are developed to treat acne by reducing excess sebum production, controlling bacterial growth, preventing follicular blockage, and reducing inflammation.

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The following formulations are commonly used in the treatment of acne vulgaris.

3.1 Topical Formulations:

3.2 Acne gel

Examples: Benzoyl peroxide gel, Clindamycin gel, Adapalene gel.

Use: Reduces acne-causing bacteria, inflammation and clogged pores.

Suitable for oily and acne-prone skin.



Fig.2. Acne gel

3.3 Acne cream:

Examples: Tretinoin cream, Azelaic acid cream.

Use: Promotes skin cell turnover and reduces comedones and inflammation.



Fig.3. Acne cream

3.4 Acne emulgel:

Examples: Clindamycin and adapalene emulgel; other suitable anti-acne combinations.

Use: Combines properties of emulsion and gel.

Provides a smooth texture and ease of application.

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Fig.4. Acne emulgel

3.5 Acne lotion:

Examples: Calamine lotion, Salicylic acid lotion.

Use: Helps control oiliness and remove dead skin cells.



Fig. 5. Acne lotion

3.6 Acne face wash:

Examples: Salicylic acid face wash, Benzoyl peroxide wash.

Use: Cleans the skin and helps reduce excess oil and acne lesions.



Fig. 6. Acne face wash

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3.8 Acne ointment:

Examples: Selected topical antibiotic or retinoid ointment preparations.

Use: Provides localized drug delivery. Less commonly preferred for oily, acne-prone facial skin because ointments may be occlusive.



Fig .7. Acne ointment

3.9 Systematic Pharmacological Therapies:

Formulation	Examples	Purpose
Tablets	Doxycycline, Minocycline	Reduce inflammation and bacterial activity.
Capsules	Isotretinoin	Treat severe nodular or resistant acne
Hormonal tablets	Combined oral contraceptives	Reduce androgen-related sebum production
Oral anti-androgen	Spironolactone	Reduce hormonal acne in appropriate patients

Tab.No.1. Classification of Formulations Used in the Treatment of Acne Vulgaris.

3.10 Nanoemulsions

Nanoemulsions are fine oil-in-water or water-in-oil dispersions containing nanosized droplets. They can improve the solubilization and topical delivery of poorly water-soluble anti-acne drugs and selected herbal constituents.

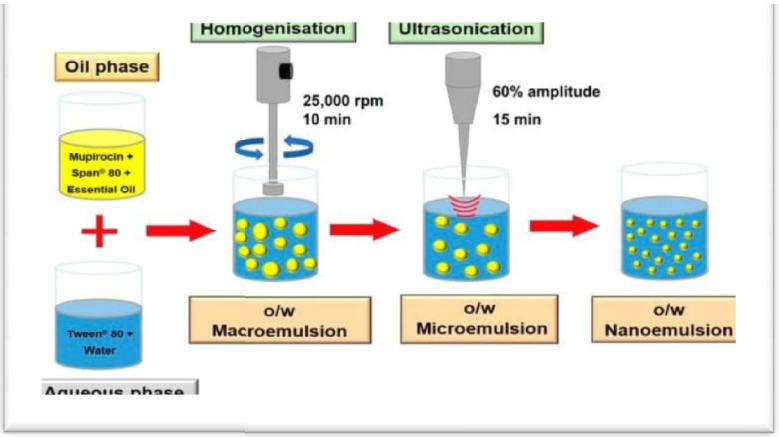

Fig. 8. Nanoemulsions

3.11 Nanoparticle-Based Formulations

Nanoparticles are investigated to improve drug stability, skin deposition and controlled drug release. Polymeric nanoparticles and lipid nanoparticles are potential carriers for topical anti-acne medications.

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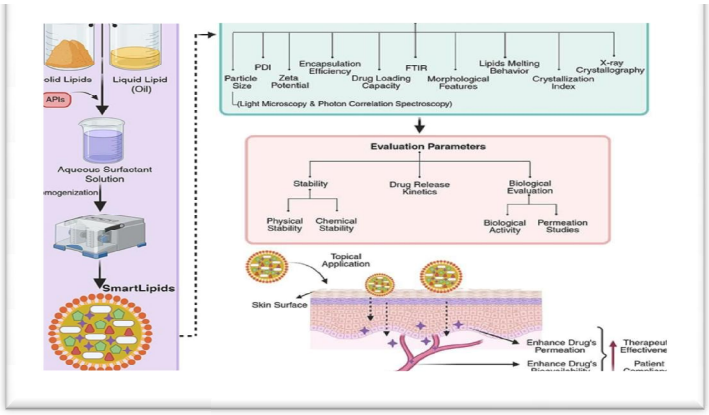

Fig.9. Nanoparticle-Based Formulations

3.12 Hydrogel Formulations:

Hydrogels are three-dimensional hydrophilic polymer networks capable of retaining large amounts of water. They provide a cooling sensation, non-greasy application and potential controlled drug release.



Fig.10. Hydrogel Formulations

IV. FORMULATION PROFILE OF HERBAL ACNE INGRIDIENTS:

4.1 Tea Tree Oil



Fig.11. Tea Tree Oil-Biological Source

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Biological name: Melaleuca alternifolia
Family: Myrtaceae
Part used: Leaves and terminal branches
Category: Essential oil
Tea tree oil is a volatile essential oil obtained from the leaves of Melaleuca alternifolia [1]. It is widely studied for its antimicrobial and anti-inflammatory properties [2].
Major chemical constituents:

- Terpinen-4-ol
- α-Terpinene
- γ-Terpinene
- 1,8-Cineole
- α-Terpineol
- Terpinolene

Pharmacological activities:
Antimicrobial activity: Tea tree oil has demonstrated activity against several microorganisms, including C. acnes in laboratory studies [1].
Anti-inflammatory activity: Certain constituents, particularly terpinen-4-ol, have been investigated for their ability to modulate inflammatory responses [2].
Skin application: Its incorporation into topical formulations may help deliver antimicrobial constituents to the skin.
Role in the proposed emulgel: Tea tree oil serves as the principal antimicrobial herbal ingredient and is intended to contribute to the management of acne-associated microbial activity.

4.2 Aloe Vera Gel



Fig.12. Aloe Vera (Aloe barbadensis Miller)

Biological name: Aloe barbadensis Miller
Family: Asphodelaceae
Part used: Leaf pulp (inner gel)
Category: Medicinal plant gel
Aloe vera is a medicinal plant commonly used in cosmetic and dermatological preparations [3]. Its inner leaf gel contains various biologically active substances [20].

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Major chemical constituents:

- Acemannan
- Glucomannan
- Polysaccharides
- Amino acids
- Vitamins
- Organic acids
- Minerals

Pharmacological activities:

Moisturizing activity: Aloe vera gel helps maintain skin hydration.

Soothing activity: It is commonly used in preparations intended to soothe irritated skin.

Wound-healing potential: Certain polysaccharides have been investigated for their role in tissue repair.

Anti-inflammatory potential: Aloe vera constituents have demonstrated anti-inflammatory effects in experimental studies [21].

Role in the proposed emulgel: Aloe vera gel acts as a moisturizing and soothing ingredient that may improve the skin feel and acceptability of the formulation [15].

V. RATIONALE FOR COMBINING TEA TREE OIL AND ALOE VERA:

The combination of tea tree oil and aloe vera is based on their potentially complementary pharmaceutical properties [3].

Tea tree oil	Aloe vera
Antimicrobial potential	Moisturizing properties
Anti-inflammatory potential	Soothing properties
Essential oil	Water-rich plant gel
Oil-soluble constituents	Hydrophilic constituents
Supports antimicrobial formulation objectives	Supports skin hydration

Table No.2 Comparative Pharmacological Properties Of Tea Tree Oil and Aloe Vera.

The combination may offer multiple benefits in a single topical preparation. Tea tree oil is intended to address microbial activity, whereas aloe vera may help maintain skin hydration and provide soothing effects [1].

However, the effectiveness of this particular combination in an emulgel must be established through formulation studies and appropriate clinical investigations. The individual properties of the ingredients do not automatically establish the efficacy of their combination [5].

VI. EMULGEL: CONCEPT AND PHARMACEUTICAL IMPORTANCE



Fig.13. Concept of Herbal Emulgel Formulation

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An emulgel is a topical drug delivery system developed by combining an emulsion with a gel base. It provides a suitable formulation approach for incorporating both hydrophilic and lipophilic ingredients [5].

Advantages of emulgel:

1.Suitable for incorporating oil-soluble and water-soluble ingredients.
2.Provides good spreadability.
3.Can offer a non-greasy and acceptable skin feel.
4. Allows uniform distribution of ingredients when properly formulated.
5. May improve the application and retention of topical preparations.
6. Provides flexibility in selecting different gelling agents and emulsifiers.

Importance in the present formulation:

Tea tree oil is incorporated into the oil phase, while aloe vera gel is incorporated into the aqueous or gel phase, subject to compatibility and stability testing [19].

VII. PROPOSED FORMULATION DEVELOPMENT

The formulation should be developed by selecting appropriate concentrations of the herbal ingredients and excipients through preliminary compatibility and optimization studies[4,27].

Proposed ingredients and their functions

Ingredient	Pharmaceutical function
Tea tree oil	Herbal antimicrobial ingredient
Aloe vera gel	Moisturizing and soothing ingredient
Lavender oil	Fragrance and Skin Conditioning agent
Carbopol 940	Gelling agent
Liquid paraffin	Oil phase
Tween 80	Emulsifying agent
Span 80	Co-emulsifying agent
Glycerin	Humectant
Disodium ETDA	Chelating agent
Triethanolamine	Neutralizing agent and pH adjustment
Propylene Glycol	Humectant and Solvent
Sodium Hydroxide	pH-adjusting agent
Methyl paraben	Preservative
Zinc Oxide	Skin Protectant and mild astringent
Propyl paraben	Preservative
Purified water	Vehicle

Table No.3 Proposed Formulation Ingridients and Their Pharmaceutical Functions.

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VIII. METHOD OF PREPARATION OF HERBAL EMULGEL



Fig.14. Preparation of Herbal Emulgel Using a Homogenizer

The herbal emulgel can be prepared using the following general procedure [4,5].

Step 1: Preparation of gel base

- Disperse Carbopol 940 gradually in purified water.
- Allow sufficient time for hydration.
- Avoid excessive stirring to minimize air entrapment.

Step 2: Preparation of oil phase

- Take the required quantity of liquid paraffin [5,19].
- Add Span 80 and mix uniformly.
- Incorporate tea tree oil at a selected, skin-safe concentration.

Step 3: Preparation of aqueous phase

- Take purified water in a separate beaker.
- Add Tween 80 and glycerin.
- Mix until a uniform aqueous phase is obtained.
- Add compatible aloe vera gel under suitable processing conditions.

Step 4: Preparation of emulsion

- Maintain suitable temperatures for the oil and aqueous phases, if heating is required.
- Add one phase gradually to the other with continuous stirring.
- Continue mixing until a uniform emulsion is obtained.
- Avoid unnecessary exposure of tea tree oil to heat.

Step 5: Incorporation into gel base

- Incorporate the prepared emulsion gradually into the hydrated gel base.
- Mix carefully until a uniform emulgel is obtained.

Step 6: pH adjustment

- Adjust the pH gradually using triethanolamine, if required.
- Check the final pH using a calibrated pH meter.

Step 7: Final preparation

- Remove entrapped air, if necessary.
- Transfer the prepared emulgel into a suitable, well-closed container.
- Label and store under appropriate conditions.

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IX. EVALUATION PARAMETERS OF HERBAL EMULGEL

The prepared herbal emulgel should be evaluated using suitable pharmaceutical quality-control tests [5,4].

9.1 Physical Appearance

The formulation is visually examined for:

- Colour
- Odour
- Texture
- Consistency
- Presence of lumps or visible particles

A uniform, smooth and aesthetically acceptable preparation is desirable.

9.2 Homogeneity Test

A small quantity of emulgel is spread between two clean glass slides [5,19].

The preparation is examined for:

- Uniform distribution
- Presence of aggregates
- Coarse particles
- Phase separation

9.3 Determination of pH



Fig.15. Determination of pH using a Digital pH Meter

Procedure:

1. Prepare a suitable aqueous dispersion of the emulgel using purified water [4,5].
2.Calibrate the digital pH meter using standard buffer solutions.
3. Immerse the electrode in the sample [4,28].
4. Allow the reading to stabilize.
5.Record the pH value.

The pH should be selected to maintain skin compatibility and formulation stability.

9.4 Viscosity Determination

Procedure:

1. Take a suitable quantity of emulgel in a clean sample container [4,5].
2. Select an appropriate spindle for the viscometer.
3. Set the required rotational speed.
4. Immerse the spindle in the sample [4,5].
5. Record the viscosity reading after stabilization.

Viscosity helps determine the consistency and flow characteristics of the formulation.

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9.5 Spreadability Test

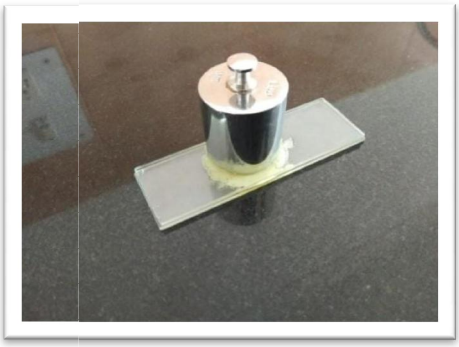

Fig.16. Spreadability Test Apparatus

Spreadability indicates how easily the formulation spreads over the skin surface [5].

Procedure:

1. Place a measured quantity of emulgel between two glass slides [19].
2. Apply a specified weight to ensure uniform spreading.
3. Attach the upper slide to a suitable arrangement.
4. Measure the time required for the upper slide to move through a specified distance under a fixed load.

9.6 Extrudability Test

Extrudability determines the ease with which emulgel can be removed from its container [5,19].

Procedure:

1. Fill a collapsible tube with the prepared emulgel.
2. Close the tube properly.
3. Apply a specified pressure.
4. Collect the extruded material.
5. Measure the quantity discharged under standardized conditions.

9.7 Drug or Active Ingredient Content

The active marker constituents of tea tree oil may be quantified using a suitable validated analytical method, such as gas chromatography [1].

The selected aloe vera marker, where appropriate, can be estimated using a validated analytical technique [15,20].

The test helps assess the consistency of active ingredient incorporation.

9.8 Antimicrobial Activity

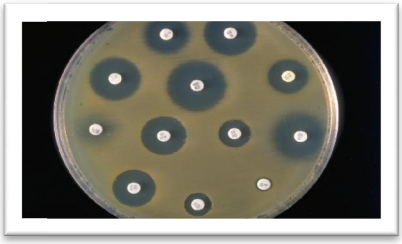

Fig.17. Antimicrobial Activity by Agar Diffusion Method

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The antimicrobial activity of the formulation may be evaluated using an appropriate agar diffusion method [1,2].

Procedure:

1. Prepare suitable agar medium.
2. Inoculate the medium with an appropriate test microorganism.
3. Prepare wells of uniform diameter.
4. Add measured quantities of the test formulation and suitable controls.
5. Incubate under organism-specific validated conditions.
6. Measure the diameter of the inhibition zones.

9.9 Stability Studies:

Stability studies are performed to determine the ability of the formulation to maintain its physical and chemical properties during storage [28,30].

Parameters to be monitored include:

- **Colour and odour changes:** Monitor visual and sensory changes during storage. No noticeable change in colour, odour or appearance.
- **pH variation**: Measure pH using a calibrated pH meter to assess skin compatibility. 5.0–6.5 (target range)
- **Viscosity changes:** Evaluate consistency and flow behaviour using a viscometer.Variation preferably within ±10% of initial viscosity.
- **Phase separation:** Observe the formulation for separation, creaming or cracking. No phase separation, creaming or cracking.
- **Active ingredient** content: Estimate the retained active constituent to assess chemical stability. 90–110% of initial content (proposed limit).
- **Microbial quality:** Assess microbial contamination to ensure product safety.

The study should follow an appropriate stability protocol, considering the formulation type and intended packaging [30].

9.10 Skin Irritation Study

Skin irritation testing is performed to assess the topical tolerability of the formulation [1,2].

The study must follow applicable ethical and regulatory requirements. A validated in-vitro skin model may be considered before any human testing [30].

Tea tree oil requires particular attention because it may cause allergic contact dermatitis or irritation in susceptible individuals [1].

X. EVALUATION PARAMETERS AND STANDARD VALUES OF HERBAL EMULGEL :

Sr. No.	Evaluation parameters	Standard value
1	Physical Appearance	Smooth, uniform and free from visible particles
2	Homogeneity	Uniform distribution; no aggregates or coarse particles
3	pH	5.0–6.5
4	Viscosity	Variation within ±10% of initial viscosity
5	Spreadability	Not specified in the article
6	Extrudability	Not specified in the article
7	Drug Content	90–110% of initial content (proposed stability limit)
8	Antimicrobial Activity	8. Presence of measurable zone of inhibition
9	Stability Studies	No phase separation, creaming or cracking
10	Skin Irritation Test	10. No irritation (specific acceptance limit not provided)

Table No.4 Evaluation Parameters and Standard Values of Herbal Emulgel

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XI. ADVANTAGES OF HERBAL EMULGEL

1. Combines the properties of an emulsion and a gel [5].
2. Can incorporate both hydrophilic and lipophilic herbal ingredients [19].
3. Offers convenient topical application [3].
4. May provide good spreadability.
5. Can be designed with a non-greasy texture [15].
6. Aloe vera may contribute to skin hydration.
7. Tea tree oil provides a potential source of antimicrobial activity.
8. Offers an opportunity to develop alternative topical delivery systems using plant-derived ingredients.

XII. LIMITATIONS

Despite its potential advantages, the proposed herbal emulgel has certain limitations [1].

1. Tea tree oil may cause skin irritation or allergic contact dermatitis.
2. Essential oils may undergo oxidation during inappropriate storage [28].
3. Herbal ingredients may show variations in chemical composition.
4. Aloe vera gel may present microbial contamination and preservation challenges [4,5].
5. The compatibility of herbal ingredients with excipients must be established.
6. Physical instability, including phase separation, may occur.
7. The combined formulation requires experimental and clinical validation [5,19].
8. The effectiveness of the formulation may vary depending on the concentration and quality of the ingredients.

XIII. DISCUSSION

As this is a review article, the following discussion summarizes expected formulation characteristics and published evidence rather than presenting newly generated experimental results [1,2].

The literature indicates that tea tree oil possesses antimicrobial properties and has been investigated for its potential application in acne management. In a randomized, double-blind, placebo-controlled study, Enshaieh et al. (2007) evaluated 5% tea tree oil gel in patients with mild-to-moderate acne vulgaris and reported improvement in acne lesions compared with placebo [3,5].

Aloe vera has been widely investigated for its moisturizing, soothing and wound-healing properties. These characteristics provide a scientific rationale for its inclusion in topical dermatological preparations [15].

The emulgel system offers a formulation approach for combining lipophilic tea tree oil with hydrophilic aloe vera gel. The selection of an appropriate emulsifier and gelling agent is important for achieving physical stability, suitable viscosity and uniform consistency.

The evaluation of pH, spreadability, viscosity, homogeneity and stability would provide information about the pharmaceutical quality of the proposed preparation. Antimicrobial testing would help investigate its activity against selected acne-associated microorganisms [5].

However, the actual performance of the combined formulation cannot be predicted solely from the individual ingredients. Further laboratory studies are required to establish its formulation characteristics, safety and anti-acne potential [9,15].

XIV. FUTURE SCOPES

The development of herbal emulgel containing tea tree oil and aloe vera gel offers several opportunities for further pharmaceutical research [4,5].

- Optimization of herbal ingredient concentrations.
- Development of improved emulsion and gel systems.
- Investigation of controlled and sustained release characteristics [30].

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- Evaluation of antimicrobial activity against C. acnes.
- Investigation of antioxidant and anti-inflammatory properties [2,6].
- Improvement of stability through suitable packaging.
- Development of standardized herbal raw materials [24].
- Further dermatological safety and clinical studies.

XV. CONCLUSION

Herbal-based topical formulations have gained considerable attention in pharmaceutical and cosmetic research because of their potential biological activities and applications in skin care. Tea tree oil (Melaleuca alternifolia) and aloe vera (Aloe barbadensis Miller) are two medicinal plant-derived ingredients with complementary properties that make them interesting candidates for a combined topical preparation [7,15].

Tea tree oil has demonstrated antimicrobial and anti-inflammatory potential, whereas aloe vera is recognized for its moisturizing, soothing and wound-healing properties. Incorporating these ingredients into an emulgel system may provide a suitable pharmaceutical approach for delivering both oil-soluble and water-soluble herbal constituents through topical application [1,3].

The proposed formulation can be evaluated through various pharmaceutical parameters, including physical appearance, homogeneity, pH, viscosity, spreadability, extrudability, active ingredient content, antimicrobial activity and stability studies [5,19].

Overall, tea tree oil and aloe vera-based herbal emulgel represents a promising research approach for potential acne management. Nevertheless, its actual therapeutic effectiveness, formulation stability and skin safety must be established through systematic laboratory investigations and well-designed clinical studies before recommending it as an anti-acne treatment [2,6,24].

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