Formulation And Evaluation of Polyherbal Nanogel for Acne Management

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***Abstract*—Acne vulgaris is one of the most prevalent dermatological disorders affecting adolescents and adults worldwide. Conventional therapies are often associated with skin irritation, dryness, and the development of microbial resistance, creating a need for safer and more effective alternatives. The present study focuses on the formulation and evaluation of a polyherbal nanogel containing orange peel extract (Citrus sinensis), ginger extract (Zingiber officinale), clove oil (Syzygium aromaticum), and eucalyptus oil (Eucalyptus globulus) for topical acne management. The selected herbal ingredients possess well-documented antimicrobial, antioxidant, and anti-inflammatory properties that may help reduce acne lesions and improve skin health. The nanogel was prepared using a suitable polymeric base and evaluated for various physicochemical parameters including appearance, pH, homogeneity, viscosity, spreadability, and stability. The developed formulation exhibited good consistency, skin-compatible pH, excellent spreadability, and satisfactory stability during storage. The nano-sized delivery system facilitated uniform distribution of active constituents and enhanced retention on the skin surface. The combined action of the herbal ingredients demonstrated potential for controlling acne-causing microorganisms and reducing inflammation. Based on the evaluation results, the formulated polyherbal nanogel may serve as a promising, safe, and effective topical alternative for acne treatment. Further in vivo and clinical studies are required to confirm its therapeutic efficacy and long-term safety.**

***Index Terms*—Acne vulgaris, Polyherbal nanogel, orange peel extract, Ginger extract, Clove oil, Eucalyptus oil, Herbal drug delivery, Topical formulation.**

I. INTRODUCTION

Acne vulgaris is one of the most prevalent inflammatory skin disorders affecting adolescents and adults worldwide [1]. It commonly appears on the face, chest, and back and is characterized by comedones, papules, pustules, and, in severe cases, permanent scarring [2]. The condition develops due to a combination of factors such as increased sebum production, hormonal fluctuations, microbial growth, and genetic susceptibility [3,4]. Owing to its widespread occurrence and psychological impact, acne continues to be an important focus of dermatological research and treatment development [5]. Recent advances in nanotechnology have led to the development of novel drug delivery systems that enhance the therapeutic performance of active ingredients [6]. Nanogels are nanoscale cross-linked polymeric networks that possess excellent biocompatibility, biodegradability, and skin penetration abilities, making them highly suitable for topical drug delivery [7]. Their unique structure enables efficient encapsulation and controlled release of bioactive compounds, thereby improving their stability and effectiveness [8]. Incorporation of herbal extracts into nanogel systems offers a promising strategy for acne management by enhancing the delivery and therapeutic action of natural anti-inflammatory and antimicrobial agents [9,2]. Acne vulgaris is a chronic inflammatory disorder of the pilosebaceous unit that commonly affects adolescents and young adults worldwide [4]. It develops due to excessive sebum production, follicular hyperkeratinization, proliferation of Cutibacterium acnes, and inflammation of the skin [2]. Conventional treatments may cause adverse effects such as skin irritation, dryness, and microbial resistance, creating a need for safer and more effective alternatives []. Polyherbal therapy has gained attention because of its ability to provide multiple therapeutic actions through natural bioactive compounds. Orange peel extract is rich in flavonoids and vitamin C, which exhibit

antioxidant and skin-brightening properties [4]. Ginger extract possesses anti-inflammatory and antimicrobial activities that help reduce acne-associated inflammation [5]. Clove oil contains eugenol, a potent antibacterial and antioxidant compound effective against acne-causing microorganisms [6]. Eucalyptus oil contributes antimicrobial and soothing effects that support skin healing and reduce irritation [7]. Nanogel-based delivery systems enhance the penetration and retention of herbal actives at the site of action, namely the pilosebaceous follicles within the skin [8]. Their nanoscale size, high biocompatibility, and controlled-release characteristics improve the therapeutic efficacy of herbal ingredients. Therefore, the formulation and evaluation of a polyherbal nanogel containing orange peel extract, ginger extract, clove oil, and eucalyptus oil may offer a promising approach for effective acne management.

Formulation Table:

Table No. 1

Sr. No	Ingredients	Quantity
1.	Ginger extract	1ml
2.	Orange peel extract	2ml
3.	Clove oil	1ml
4.	Eucalyptus oil	1ml
5.	Glycerin	1.5ml
6.	Propylene glycol	2.5ml
7.	Tween 20	20ml
8.	Carbapol 934	1.25gm
9.	Triethanolamine	1-2drops
10.	Distilled water	Q. s

II. STUDY AIM AND OBJECTIVE:

Aim: To formulate and evaluate a polyherbal nanogel containing orange peel extract, ginger extract, clove oil, and eucalyptus oil for the effective management of acne vulgaris by improving the topical delivery and therapeutic activity of herbal bioactive compounds [6,8].

Objectives:

- To select herbal ingredients with proven anti-acne, antimicrobial, anti-inflammatory, and antioxidant properties [10,13].
- To prepare a stable polyherbal nanogel suitable for topical application.
- To evaluate the physicochemical characteristics of the formulated nanogel, including appearance, pH, viscosity, spreadability, and homogeneity.
- To determine the particle size and stability of the prepared nanogel formulation.
- To study the release behavior and skin permeation of the herbal active constituents from the nanogel system [8].
- To assess the antimicrobial activity of the formulation against acne-causing microorganisms.
- To evaluate the overall effectiveness of the developed polyherbal nanogel as a potential treatment for acne vulgaris.

III. MATERIAL AND METHODS

Table no.2 Material

Sr.no	Ingredients	properties
1	Ginger extract	Anti inflammatory
2	Orange peel extact	Antioxidant
3	Clove oil	Antiacne
4	Eucalyptus oil	Antimicrobial
5	Propylene glycol	penetration enhancer
6	Carbapol 934	Gelbase
7	Glycerine	Moisturizer
8	Tween 20	Surfactant
9	triethanolamine	pH adjusent

The materials used in the formulation of the Polyherbal nanogel for acne management. The details of ingredients and their pharmaceutical functions are given below

Role/Function in Formulation:

1. Ginger Extract (Zingiber officinale)

Acts as an anti-inflammatory and antioxidant agent that helps reduce acne-associated inflammation and oxidative stress [14]

2. Orange Peel Extract (Citrus sinensis)

Provides antioxidant protection due to its flavonoid and vitamin C content, helping to protect skin from free radical damage [10].

3. Eucalyptus Oil (Eucalyptus globulus)

Functions as a natural antimicrobial agent that helps control acne-causing microorganisms and soothes irritated skin [15]

4. Clove Oil (Syzygium aromaticum)
Exhibits antimicrobial and antioxidant properties that assist in preventing bacterial growth and promoting healthy skin [16].

5. Propylene Glycol
Serves as a penetration enhancer, improving the delivery of active ingredients through the skin [17].

6. Carbopol 934
Acts as a gelling agent that provides suitable viscosity and stability to the nanogel formulation [17].

7. Triethanolamine
Used to adjust pH and neutralize Carbopol, resulting in the formation of a stable gel structure [17].

8. Glycerin
Functions as a humectant that retains moisture in the skin and prevents dryness after application [17].

9. Tween 20
Acts as a surfactant and emulsifying agent that improves the dispersion and stability of oil-based ingredients in the formulation [17].

METHODS:
Preparation of Polyherbal Nanogel
Orange peel extract, ginger extract, clove oil, and eucalyptus oil were selected as active herbal ingredients based on their reported antimicrobial, antioxidant, and anti-inflammatory properties that may contribute to the management of acne vulgaris [18–20].
The required quantities of orange peel extract and ginger extract were dissolved in a suitable hydroalcoholic medium under continuous stirring. Clove oil and eucalyptus oil were subsequently incorporated into the mixture to obtain a uniform herbal phase. The dispersion was subjected to high-speed homogenization followed by ultrasonication to reduce particle size and improve the distribution of phytoconstituents within the system. The resulting nano-dispersion was allowed to stabilize before incorporation into the gel base [8].
For preparation of the gel base, Carbopol 940 was gradually dispersed in purified water and allowed to hydrate completely. Propylene glycol was added as a humectant and permeation enhancer, while methyl paraben and propyl paraben were incorporated as preservatives. The hydrated polymeric dispersion was stirred continuously until a smooth and homogeneous gel base was obtained [21].
The prepared nano-dispersion was slowly added to the hydrated gel base under constant stirring. Triethanolamine was added dropwise to neutralize the Carbopol and adjust the pH to a skin-compatible range of 6.0–7.0. The formulation was mixed thoroughly to ensure uniform distribution of the nano-sized herbal constituents throughout the gel matrix. The final polyherbal nanogel was transferred into airtight containers and stored at room temperature for further evaluation [8,21].

IV. EVALUATION PARAMETRS OF NANOGEL

Nanogel evaluation is an important step in pharmaceutical formulation. It helps to ensure that tablets are safe, effective, stable, and of good quality. Different tests are performed to check the physical appearance, stability, etc.

1. Physical Characteristics
The developed nanogel was examined visually for its color, appearance, texture, and uniformity. The formulation was considered acceptable when it exhibited a smooth consistency without visible aggregates, grittiness, or phase separation [8].

2. Determination of pH
The pH of the formulation was measured using a calibrated digital pH meter. One gram of nanogel was dispersed in distilled water and allowed to equilibrate before measurement. Maintaining a pH close to that of the skin is important to minimize irritation and improve patient compliance [22].

3. Homogeneity Assessment
A small quantity of nanogel was spread on a clean glass slide and inspected visually for the presence of lumps, coarse particles, or inconsistencies. A homogeneous formulation indicates proper distribution of the active ingredients throughout the gel matrix [23].

4. Viscosity Measurement
The rheological behavior of the nanogel was determined using a Brookfield viscometer under

controlled conditions. Appropriate viscosity is essential for ensuring ease of application, adequate residence time on the skin, and formulation stability [21].

5. Spreadability Study

Spreadability was evaluated to determine the ease with which the formulation could be distributed over the skin surface. Good spreadability facilitates uniform application and improves therapeutic effectiveness of the topical preparation [24].

6. Extrudability Test

The ability of the formulation to be expelled from a collapsible tube was assessed by applying gentle pressure. A satisfactory formulation should be extruded easily without excessive force, ensuring convenient patient use [23].

7. Particle Size Analysis

The mean particle size and particle size distribution of the nanogel were determined using dynamic light scattering techniques. Reduction in particle size enhances surface area, improves skin penetration, and may increase the bioavailability of herbal constituents [8].

8. Antimicrobial Activity

The antimicrobial effectiveness of the polyherbal nanogel was investigated against acne-associated microorganisms using the agar well diffusion technique. The antimicrobial activity was assessed by measuring the diameter of the inhibition zone produced around the sample [24].

V. RESULT AND DISCUSSION

The parameter for assessing the result of polyherbal nanogel.

Table no.3 Parameter and Result

Sr.no.	Parameter	Result
1.	Color	Pale yellow
2.	Appearance	Transparent
3.	pH	5.6
4.	Viscosity	5485cps
5.	Spreadability	7.2g.cm/sec
6.	Texture	Smooth
7.	Homogenicity	Excellent
8.	Odor	Pleasant
9.	Partical size	178.5nm

Discussion

The developed polyherbal nanogel showed good physical stability, homogeneity, and a skin-compatible pH, indicating its suitability for topical application [1]. The formulation exhibited appropriate viscosity and spreadability, which may enhance application and retention on the skin. The nanosized system is expected to improve skin penetration and delivery of herbal actives. The antimicrobial effect may be due to the combined action of orange peel, ginger, clove oil, and eucalyptus oil against acne-causing bacteria [2].

VI. CONCLUSION

The present investigation successfully developed and evaluated a polyherbal nanogel containing orange peel extract, ginger extract, clove oil, and eucalyptus oil for potential anti-acne application. The study was initiated based on the multifactorial pathogenesis of acne vulgaris, which includes bacterial proliferation, inflammation, and excess sebum production [1]. The formulated nanogel demonstrated satisfactory physicochemical properties, including uniform appearance, appropriate pH, good viscosity, and adequate spreadability, indicating its suitability for topical administration. The incorporation of herbal extracts into a nanogel system enhanced the stability and potential delivery of bioactive compounds to the targeted skin layers [8]. The nanosized formulation is expected to improve skin penetration and increase the therapeutic efficiency of the active constituents. Additionally, the synergistic antimicrobial and anti-inflammatory effects of the selected herbal ingredients suggest potential effectiveness against acne-causing microorganisms such as Cutibacterium acnes [20]. Overall, the findings indicate that the developed polyherbal nanogel may serve as a promising, safe, and effective herbal alternative for acne management. However, further in vivo studies and clinical evaluations are necessary to confirm its long-term safety, pharmacological efficacy, and therapeutic superiority over conventional formulations [22].

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