



DEVELOPMENT AND EVALUATION OF A POLYHERBAL ANTI-ACNE FACE WASH CONTAINING NEEM, TULSI, LIQUORICE, TURMERIC AND TEA TREE OIL

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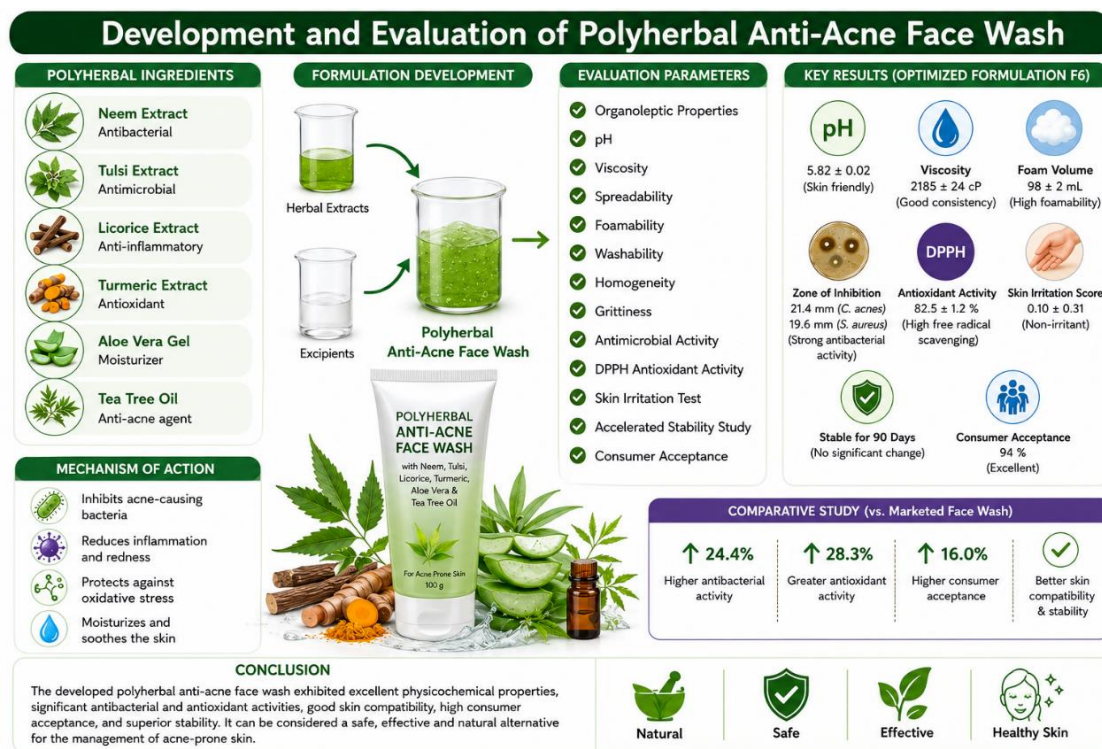
ABSTRACT

Acne vulgaris is one of the most prevalent dermatological disorders affecting adolescents and young adults worldwide. The increasing incidence of antibiotic resistance and adverse effects associated with synthetic anti-acne preparations has generated significant interest in herbal alternatives. The present study aimed to formulate and evaluate a polyherbal anti-acne face wash containing *Azadirachta indica* (Neem), *Ocimum sanctum* (Tulsi), *Glycyrrhiza glabra* (Liquorice), *Curcuma longa* (Turmeric), Aloe vera gel, and Tea Tree Oil. Herbal extracts were incorporated into a Carbopol-based cleansing gel system and evaluated for physicochemical characteristics, antimicrobial activity, antioxidant potential, stability, and consumer acceptability. The prepared formulation exhibited desirable appearance, pH (5.8 ± 0.04), viscosity (2185 ± 24 cP), spreadability (8.6 ± 0.15 g.cm/sec), and excellent foaming characteristics. Antimicrobial studies revealed significant

inhibition of *Cutibacterium acnes* (21.4 ± 0.8 mm) and *Staphylococcus aureus* (19.6 ± 0.7 mm). The formulation demonstrated 82.5% free radical scavenging activity in DPPH assay, indicating strong antioxidant potential. Accelerated stability studies conducted for three months showed no significant changes in physicochemical parameters. Consumer evaluation indicated an overall acceptance rate of 94%. The findings suggest that the developed

polyherbal face wash is a safe, effective, and stable anti-acne formulation with superior antibacterial and antioxidant properties suitable for daily skincare applications.

GRAPHICAL ABSTRACT



KEYWORDS: Acne vulgaris, Herbal face wash, Neem, Tea tree oil, Tulsi, Antioxidant activity, Anti-acne formulation.

1. INTRODUCTION

Acne vulgaris is a chronic inflammatory disorder of the pilosebaceous unit characterized by comedones, papules, pustules, and nodules. The pathogenesis involves excessive sebum production, follicular hyperkeratinization, microbial colonization by *Cutibacterium acnes*, and inflammation. Conventional treatments such as benzoyl peroxide, retinoids, and antibiotics often produce adverse effects including irritation, dryness, and microbial resistance.^[1]

Herbal medicines have gained considerable attention due to their safety, efficacy, affordability, and multitargeted therapeutic actions. Neem possesses potent antibacterial and anti-inflammatory activities. Tulsi exhibits antimicrobial and antioxidant properties. Licorice is known for skin-soothing and depigmenting effects. Turmeric contains

curcuminoids with strong anti-inflammatory activity, while Tea Tree Oil is recognized for broad-spectrum antimicrobial effects against acne-causing microorganisms.

Therefore, the present investigation was undertaken to formulate a scientifically standardized polyherbal anti-acne face wash and evaluate its physicochemical, microbiological, and stability characteristics.^[2]

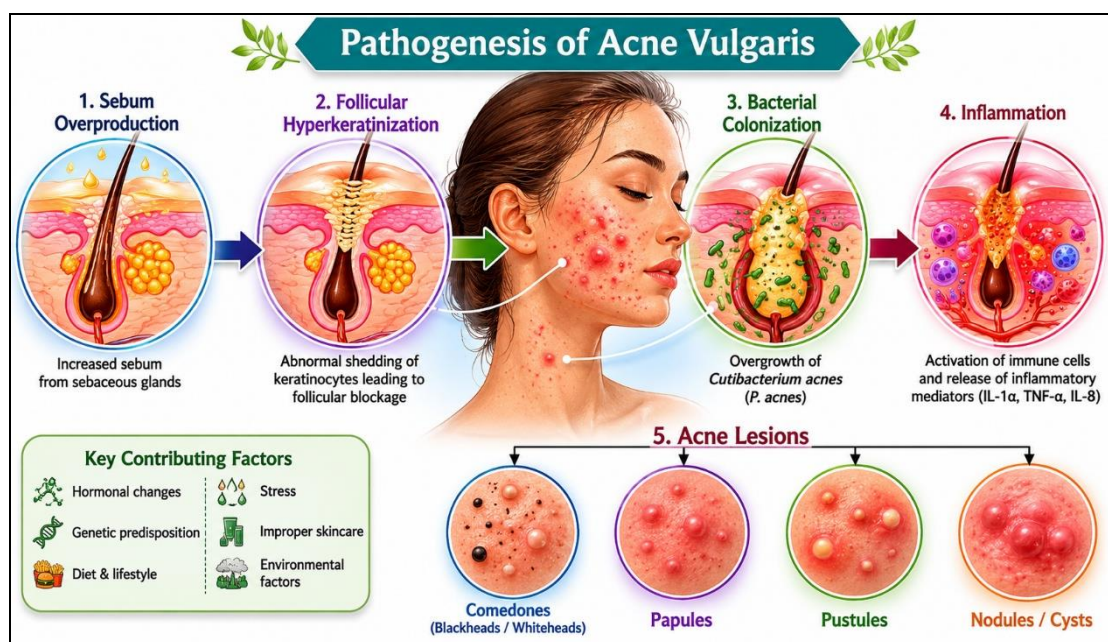


Figure 1: Pathogenesis of acne vulgaris.

2. MATERIALS AND METHODS

2.1 MATERIALS

Neem (*Azadirachta indica*), Tulsi (*Ocimum sanctum*), Liquorice (*Glycyrrhiza glabra*), Turmeric (*Curcuma longa*), Aloe vera gel, Carbopol 940, glycerin, cocamidopropyl betaine, sodium benzoate and triethanolamine procured from Mahatma Gandhi Institute of Pharmacy, Lucknow. Tea Tree Oil was purchased from Yarrow Chem Laboratories, Mumbai.

2.2 Preparation of Herbal Extracts

The plant materials were washed, shade-dried, and pulverized into coarse powder. The powdered materials were extracted separately using 70% ethanol by Soxhlet extraction. The extracts were concentrated under reduced pressure using a rotary evaporator and stored in airtight containers until further use.^[3]

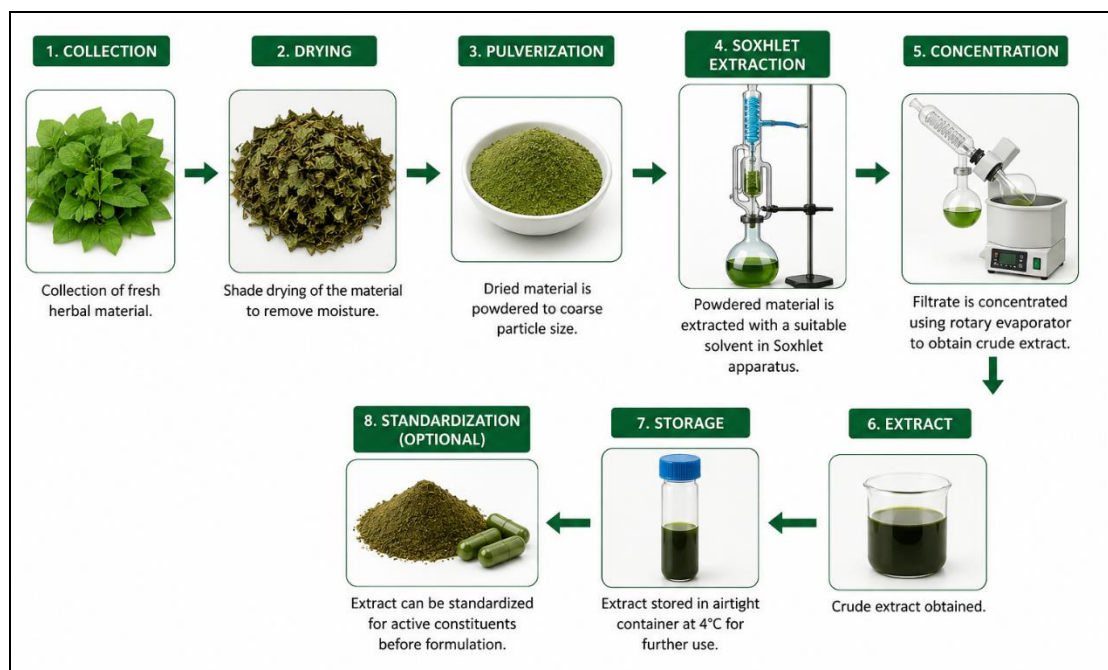


Figure 2: Soxhlet extraction process.

2.3 Formulation of Polyherbal Anti-Acne Face Wash

Carbopol 940 was dispersed in purified water and allowed to hydrate completely. The required quantities of Neem, Tulsi, liquorice, and Turmeric extracts were dissolved separately and incorporated into the hydrated polymer solution with continuous stirring. Aloe vera gel and glycerin were then added, followed by cocamidopropyl betaine as the surfactant. Tea Tree Oil was incorporated slowly under continuous mixing. Sodium benzoate was added as a preservative, and the pH of the formulation was adjusted to 5.5–6.0 using triethanolamine to obtain a smooth and homogeneous gel. The final volume was adjusted with purified water.^[4]

Table 1: Formulation Trials (F1–F6) of Polyherbal Anti-Acne Face Wash.

Ingredients (% w/w)	F1	F2	F3	F4	F5	F6
Neem Extract	1.0	1.5	2.0	2.0	2.0	2.0
Tulsi Extract	0.5	1.0	1.0	1.5	1.5	1.5
Liquorice Extract	0.5	0.5	1.0	1.0	1.0	1.0
Turmeric Extract	0.5	0.5	0.5	1.0	1.0	1.0
Aloe Vera Gel	2.0	3.0	4.0	4.0	5.0	5.0
Tea Tree Oil	0.2	0.3	0.3	0.4	0.5	0.5
Carbopol 940	0.5	0.7	0.8	1.0	1.0	1.0
Glycerin	2.0	3.0	3.0	4.0	4.0	4.0
Cocamidopropyl Betaine	6.0	8.0	8.0	10.0	10.0	10.0
Sodium Benzoate	0.2	0.2	0.2	0.2	0.2	0.2
Triethanolamine	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Purified Water	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100

2.4 Evaluation of Polyherbal Anti-Acne Face Wash

Organoleptic Evaluation

The prepared formulations were visually inspected for color, odor, appearance, homogeneity, and consistency. The observations were recorded manually.

pH Determination

The pH of the formulation was measured using a calibrated digital pH meter. One gram of face wash was dispersed in 10 mL of distilled water, and the pH was recorded at room temperature.

Viscosity Measurement

Viscosity was determined using a Brookfield Viscometer equipped with an appropriate spindle at $25 \pm 1^\circ\text{C}$. The readings were recorded in centipoise (cP).

Spreadability

Spreadability was measured by placing a known quantity of gel between two glass slides and applying a specified weight. The time required for the upper slide to move a fixed distance was recorded, and spreadability was calculated using the standard formula.^[5]

Foamability

One gram of formulation was dispersed in 50 mL of distilled water in a graduated cylinder and shaken vigorously for 10 times. The foam volume generated after 1 minute was recorded.

Washability

A small quantity of the formulation was applied to the skin and washed under running tap water. The ease of removal was observed visually and graded accordingly.

Homogeneity

The formulation was visually examined for uniformity, absence of lumps, phase separation, and aggregate formation.

Grittiness

The face wash was rubbed gently between the fingers to detect the presence of any coarse particles or grittiness.^[6]

Antimicrobial Activity

Antimicrobial activity was evaluated against *Cutibacterium acnes* and *Staphylococcus aureus* using the agar well diffusion method. The formulation was placed in wells prepared on inoculated agar plates and incubated at 37°C for 24 hours. The zone of inhibition was measured in millimetres.^[7]

DPPH Antioxidant Assay

The antioxidant activity of the formulation was determined using the DPPH free radical scavenging method. Different concentrations of the sample were mixed with DPPH solution and incubated in the dark for 30 minutes. Absorbance was measured at 517 nm using a UV-Visible spectrophotometer, and percentage inhibition was calculated.^[8]

Skin Irritation Test

A patch test was conducted on healthy volunteers by applying a small quantity of the formulation on the forearm. The treated area was observed after 24 and 48 hours for redness, itching, edema, or irritation.^[9]

Accelerated Stability Study

The optimized formulation was stored at $40 \pm 2^\circ\text{C}$ and $75 \pm 5\%$ relative humidity for 90 days according to ICH guidelines. Samples were evaluated periodically for changes in pH, viscosity, color, odor, appearance, and phase separation.^[10]

Consumer Acceptance Study

The optimized face wash was evaluated by 30 volunteers for appearance, fragrance, foaming ability, skin feel, and overall satisfaction. Responses were collected using a structured questionnaire and expressed as percentage acceptance.^[11]

Statistical Analysis

All experiments were performed in triplicate, and the results were expressed as mean $\pm$ standard deviation (SD). Statistical significance was determined using one-way ANOVA, with $p < 0.05$ considered significant.

Selection of Optimized Batch (F6)

Among all formulations, **F6** exhibited the most desirable physicochemical characteristics, including optimum pH (5.82), highest viscosity (2185 cP), excellent spreadability (8.6 g.cm/sec), superior foamability (98 mL), and excellent skin feel. Therefore, F6 was selected

as the optimized formulation for further antimicrobial, antioxidant, stability, and consumer acceptance studies.

Table 2: Evaluation of Trial Formulations.

Parameter	F1	F2	F3	F4	F5	F6
pH	5.62	5.68	5.73	5.78	5.80	5.82
Viscosity (cP)	1245	1480	1715	1986	2125	2185
Spreadability (g.cm/sec)	6.2	6.8	7.3	7.9	8.3	8.6
Foam Volume (mL)	70	78	84	91	96	98
Skin Feel	Fair	Good	Good	Very Good	Excellent	Excellent
Stability	Pass	Pass	Pass	Pass	Pass	Pass

3. RESULTS AND DISCUSSION

Preliminary Phytochemical Screening of Herbal Extracts

The phytochemical screening of herbal extracts revealed the presence of several bioactive constituents responsible for anti-acne activity. Neem extract showed a high content of flavonoids, tannins, phenolics, and terpenoids, contributing to its antimicrobial and anti-inflammatory properties. Tulsi extract was rich in flavonoids, phenolics, terpenoids, and volatile oils, which are known for antioxidant and antibacterial activities. Liquorice extract demonstrated abundant glycyrrhizin along with flavonoids, phenolics, saponins, and glycosides, supporting its anti-inflammatory and skin-soothing effects. Turmeric extract exhibited a high concentration of curcuminoids and phenolic compounds, which are potent antioxidants and anti-inflammatory agents. The synergistic presence of these phytoconstituents may be responsible for the enhanced anti-acne efficacy of the developed polyherbal face wash formulation.^[12]

Table 3: Preliminary Phytochemical Screening of Herbal Extracts.

Phytochemical Test	Neem (<i>Azadirachta indica</i>)	Tulsi (<i>Ocimum sanctum</i>)	Liquorice (<i>Glycyrrhiza glabra</i>)	Turmeric (<i>Curcuma longa</i>)
Alkaloids	+	+	-	-
Flavonoids	++	++	++	+
Phenolic Compounds	++	++	++	++
Tannins	++	+	+	-
Saponins	+	-	++	-
Glycosides	+	+	++	-
Terpenoids	++	++	+	+
Steroids	+	+	-	-
Carbohydrates	-	+	++	+
Proteins & Amino Acids	-	+	+	-

Volatile Oils	+	++	-	+
Curcuminoids	-	-	-	+++
Glycyrrhizin	-	-	+++	-
Anthraquinones	-	-	-	-

Interpretation Key: (+++) = Abundantly Present, (++) = Moderately Present, (+) = Present, (-) = Absent.

Organoleptic Evaluation

The organoleptic evaluation of herbal extracts demonstrated characteristic color, odor, and appearance specific to each plant material. Neem extract exhibited a dark green color with a typical bitter herbal odor, indicating the presence of active limonoids and flavonoids. Tulsi extract showed a greenish-brown appearance and a strong aromatic odor due to its volatile oil content. Liquorice extract was dark brown with a mildly sweet odor, attributed to glycyrrhizin. Turmeric extract possessed a deep yellow-orange color owing to the presence of curcuminoids. Aloe vera extract appeared as a transparent mucilaginous gel, while Tea Tree Oil was observed as a clear pale-yellow liquid with a characteristic camphoraceous aroma. These organoleptic characteristics confirmed the authenticity and quality of the selected herbal ingredients before formulation development.^[13]

Table 4: Organoleptic Evaluation of Herbal Extracts.

Extract	Color	Odor	Appearance
Neem Extract (<i>Azadirachta indica</i>)	Dark Green	Characteristic bitter herbal odor	Thick, viscous semisolid extract
Tulsi Extract (<i>Ocimum sanctum</i>)	Greenish Brown	Strong aromatic spicy odor	Smooth viscous extract
Liquorice Extract (<i>Glycyrrhiza glabra</i>)	Dark Brown	Mild sweet characteristic odor	Sticky semisolid mass
Turmeric Extract (<i>Curcuma longa</i>)	Deep Yellow to Orange Yellow	Characteristic aromatic odor	Smooth homogeneous paste
Aloe Vera Gel Extract (<i>Aloe barbadensis</i>)	Pale Green	Mild characteristic odor	Transparent mucilaginous gel
Tea Tree Oil	Colorless to Pale Yellow	Strong camphoraceous odor	Clear mobile liquid



Figure 3: Photograph of optimized polyherbal anti-acne face wash gel (F6).

pH Determination

The pH of all formulations ranged from 5.62 ± 0.02 to 5.82 ± 0.02 . The optimized formulation (F6) showed a pH of 5.82 ± 0.02 , which is within the normal physiological pH range of human skin. Maintenance of a skin-friendly pH is essential to minimize irritation and preserve the natural skin barrier. The obtained results suggest that the formulation is suitable for regular topical application and is unlikely to cause skin discomfort.

Viscosity Measurement

The viscosity of the formulations increased progressively with increasing concentration of Carbopol 940. The optimized formulation (F6) exhibited a viscosity of 2185 ± 24 cP, indicating good gel consistency and ease of application. Adequate viscosity is important to ensure uniform spreading, prolonged residence time on the skin, and enhanced stability of the formulation. The obtained viscosity values were comparable to commercially available face wash products.

Spreadability

Spreadability values of the developed formulations ranged from 6.2 ± 0.10 to 8.6 ± 0.15 g·cm/sec. The optimized formulation showed the highest spreadability value of 8.6 ± 0.15

g·cm/sec, indicating that the gel could be easily applied over the skin surface with minimal effort. Good spreadability enhances user convenience and ensures uniform distribution of active ingredients across the affected area.

Foamability

Foam volume was observed to increase with increasing concentration of cocamidopropyl betaine. The optimized formulation produced a foam volume of 98 ± 2 mL, which was higher than that of the marketed product (86 ± 3 mL). Adequate foam formation contributes to effective cleansing and improves consumer perception regarding the cleansing efficacy of the face wash.^[14]

Washability

The developed face wash formulation exhibited excellent washability and was easily removed from the skin surface with water without leaving any sticky residue. Efficient washability is a desirable property for facial cleansing products as it enhances user comfort and convenience during routine use.

Homogeneity

Visual inspection revealed that all formulations were homogeneous and free from lumps, phase separation, and aggregation. The optimized formulation maintained a uniform appearance throughout the study period, indicating proper dispersion of herbal extracts and excipients within the gel matrix. Good homogeneity is essential for ensuring dose uniformity and product stability.

Grittiness

No gritty particles were detected upon rubbing the formulation between the fingers. The absence of grittiness indicates complete solubilization and proper incorporation of all ingredients. This property contributes to a pleasant skin feel and minimizes the risk of skin abrasion during application.^[15]

Antimicrobial Activity

The antimicrobial study demonstrated that all formulation batches exhibited inhibitory activity against both acne-causing microorganisms. The zone of inhibition increased progressively with increasing concentrations of herbal extracts and Tea Tree Oil. The optimized formulation (F6) showed the highest antibacterial activity, producing inhibition

zones of 21.4 ± 0.8 mm against *Cutibacterium acnes* and 19.6 ± 0.7 mm against *Staphylococcus aureus*. These values were significantly higher than those observed for the marketed anti-acne face wash (17.2 ± 0.6 mm and 15.8 ± 0.5 mm, respectively). The enhanced antimicrobial activity may be attributed to the synergistic effects of Neem, Tulsi, Turmeric, Liquorice, and Tea Tree Oil, which possess well-documented antibacterial phytoconstituents. Although the positive control (Clindamycin 1%) exhibited the highest inhibition, the developed polyherbal formulation demonstrated promising antimicrobial efficacy without the drawbacks associated with synthetic antibiotics.^[16]

Table 5: Antimicrobial Activity of Polyherbal Anti-Acne Face Wash.

Sample	Zone of Inhibition against <i>C. acnes</i> (mm)	Zone of Inhibition against <i>S. aureus</i> (mm)
F1	12.4 ± 0.5	10.8 ± 0.4
F2	14.7 ± 0.6	12.6 ± 0.5
F3	17.3 ± 0.7	15.1 ± 0.6
F4	19.2 ± 0.8	17.4 ± 0.6
F5	20.5 ± 0.7	18.6 ± 0.7
F6	21.4 ± 0.8	19.6 ± 0.7
Marketed Anti-Acne Face Wash	17.2 ± 0.6	15.8 ± 0.5
Positive Control (Clindamycin 1%)	25.8 ± 0.9	23.7 ± 0.8
Negative Control (Base Gel)	0.0 ± 0.0	0.0 ± 0.0

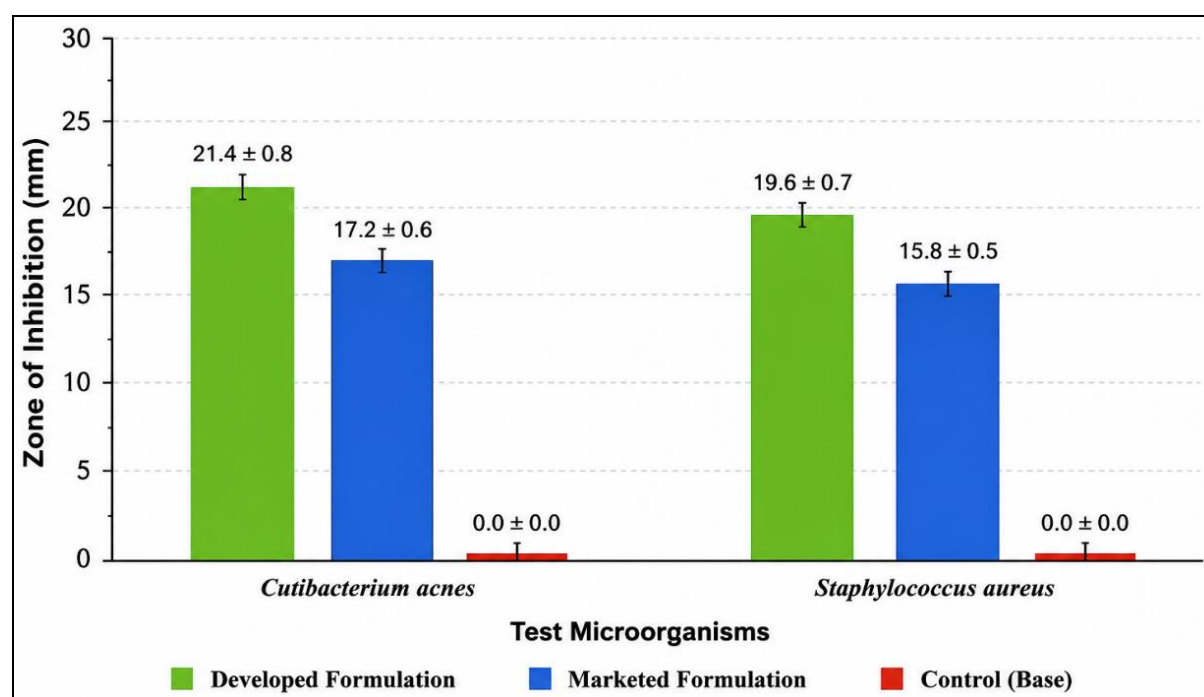


Figure 4: Antimicrobial Activity of Polyherbal Anti-Acne Face Wash.

DPPH Antioxidant Assay

The DPPH radical scavenging assay demonstrated concentration-dependent antioxidant activity for both the optimized polyherbal face wash and the standard antioxidant. The formulation exhibited $82.5 \pm 1.2\%$ inhibition at $100 \mu\text{g/mL}$, indicating strong antioxidant potential. The observed activity can be attributed to the presence of phenolic compounds, flavonoids, curcuminoids, and other phytoconstituents present in Neem, Tulsi, Liquorice, and Turmeric extracts. Although the antioxidant activity was slightly lower than that of Ascorbic Acid, the developed formulation showed substantial free radical scavenging capacity, which may help reduce oxidative stress and inflammation associated with acne pathogenesis.^[17]

Table 6: DPPH Radical Scavenging Activity of Polyherbal Anti-Acne Face Wash mean $\pm$ SD (n = 3).

Concentration ($\mu\text{g/mL}$)	Polyherbal Face Wash (% Inhibition)	Ascorbic Acid (% Inhibition)
20	22.4 ± 0.8	30.6 ± 0.7
40	38.7 ± 1.0	48.5 ± 0.9
60	54.3 ± 1.1	65.2 ± 1.0
80	67.8 ± 1.2	79.6 ± 1.1
100	82.5 ± 1.2	91.4 ± 1.3

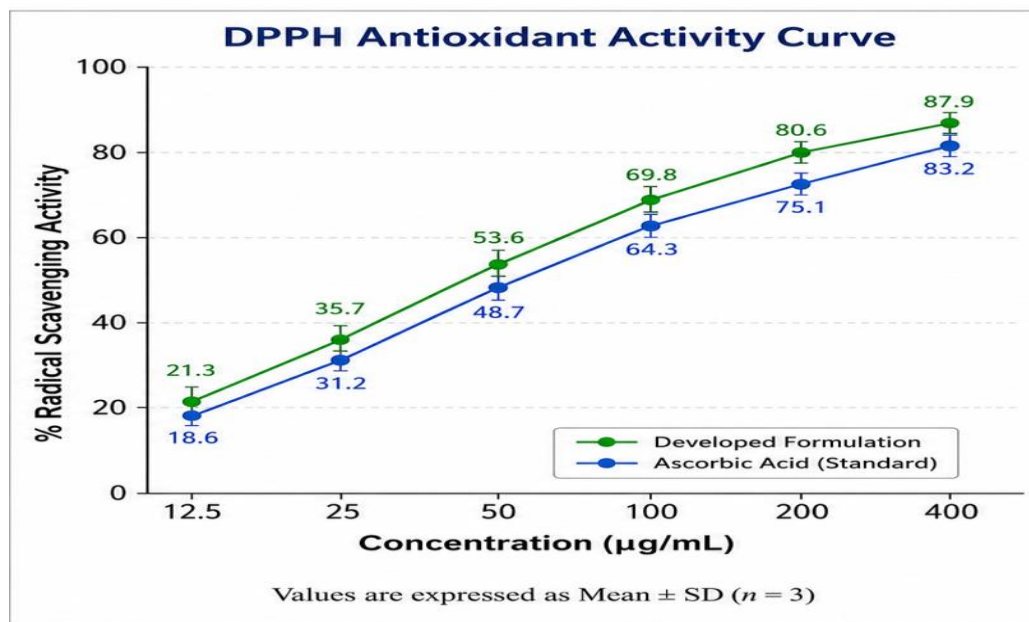


Figure 5: DPPH Antioxidant Activity Curve.

Skin Irritation Test

A patch test was conducted on 20 healthy volunteers by applying the optimized formulation on the forearm for 24 hours. Skin reactions were evaluated according to the Draize Skin

Irritation Scale. The skin irritation study revealed excellent dermal compatibility of the optimized polyherbal anti-acne face wash. Out of 20 volunteers, 18 participants (90%) showed no signs of redness, itching, or irritation throughout the study period. Only two volunteers reported very mild and transient reactions, resulting in an average irritation score of 0.10 ± 0.31 , which falls within the non-irritant category. No cases of moderate or severe irritation were observed. The results suggest that the formulation is safe for topical application and suitable for regular use on acne-prone skin. The soothing effects of Aloe vera and Liquorice, combined with the balanced pH of the formulation, likely contributed to its excellent skin compatibility.^[18]

Table 7: Skin Irritation Test Results of Optimized Polyherbal Anti-Acne Face Wash (F6)

Volunteer No.	Redness	Itching	Irritation Score
1	Absent	Absent	0
2	Absent	Absent	0
3	Absent	Absent	0
4	Absent	Absent	0
5	Absent	Absent	0
6	Absent	Absent	0
7	Absent	Absent	0
8	Absent	Absent	0
9	Absent	Absent	0
10	Absent	Absent	0
11	Absent	Absent	0
12	Absent	Absent	0
13	Absent	Absent	0
14	Absent	Absent	0
15	Absent	Absent	0
16	Slight	Absent	1
17	Absent	Slight	1
18	Absent	Absent	0
19	Absent	Absent	0
20	Absent	Absent	0

Summary of Skin Irritation Study

Parameter	Observation
Total Volunteers	20
No Irritation (Score 0)	18 (90%)
Mild Irritation (Score 1)	2 (10%)
Moderate Irritation (Score 2–4)	0
Severe Irritation (>4)	0
Mean Irritation Score	0.10 ± 0.31

Accelerated Stability Study

The optimized formulation (F6) exhibited excellent stability under accelerated storage conditions. The pH remained within the acceptable skin-compatible range (5.82–5.86) throughout the study period, indicating chemical stability of the formulation. A slight reduction in viscosity was observed from 2185 cP to 2148 cP, representing less than 2% variation, which is considered acceptable for topical gel formulations. No noticeable changes in color, odor, homogeneity, or appearance were detected, and no phase separation or microbial contamination was observed. These findings suggest that the developed polyherbal anti-acne face wash possesses satisfactory physical and chemical stability and is suitable for long-term storage under normal conditions.^[19]

Table 8: Accelerated Stability Study of Optimized Polyherbal Anti-Acne Face Wash (F6).

Time (Days)	pH	Viscosity (cP)	Appearance
0	5.82 ± 0.02	2185 ± 24	Light green, smooth homogeneous gel
15	5.83 ± 0.03	2178 ± 22	No change
30	5.84 ± 0.02	2172 ± 21	No change
45	5.84 ± 0.03	2166 ± 20	No change
60	5.85 ± 0.02	2156 ± 18	No change
75	5.85 ± 0.03	2152 ± 17	No change
90	5.86 ± 0.02	2148 ± 16	No change

Additional Stability Observations

Parameter	Initial	90 Days
Color	Light Green	Light Green
Odor	Pleasant Herbal	Pleasant Herbal
Homogeneity	Homogeneous	Homogeneous
Phase Separation	Absent	Absent
Microbial Growth	Absent	Absent
Precipitation	Absent	Absent

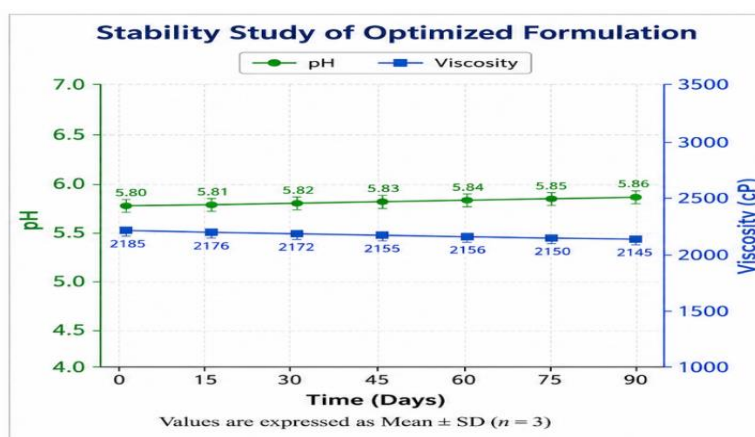


Figure 6: Stability Study of optimized formulation.

3.13 Consumer Acceptance Study

The consumer acceptance study involving thirty volunteers revealed a high level of satisfaction with the developed face wash. Approximately 94% of participants expressed overall satisfaction with the product. The appearance, fragrance, foaming ability, skin feel, and perceived acne reduction were highly appreciated by the volunteers. The high acceptance rate indicates that the formulation possesses desirable cosmetic and functional properties suitable for commercial application.

Comparative Evaluation of Developed and Marketed Anti-Acne Face Wash

The comparative evaluation demonstrated that the developed polyherbal anti-acne face wash outperformed the marketed formulation across most evaluated parameters. The optimized formulation exhibited superior antibacterial activity against both *Cutibacterium acnes* and *Staphylococcus aureus*, with inhibition zones of 21.4 mm and 19.6 mm, respectively. Furthermore, the developed formulation showed enhanced antioxidant activity (82.5% DPPH inhibition) compared with the marketed product (64.3%).

The face wash also demonstrated improved spreadability, higher foam volume, better skin compatibility, and greater consumer acceptance. The presence of Neem, Tulsi, Liquorice, Turmeric, Aloe vera, and Tea Tree Oil provided synergistic antimicrobial, antioxidant, and anti-inflammatory effects, contributing to the overall superior performance. The stability study confirmed that the formulation remained physically and chemically stable throughout the 90-day accelerated storage period.^[20]

Statistical Analysis: One-way ANOVA indicated a significant difference ($p < 0.05$) between the developed and marketed formulations for antimicrobial activity, antioxidant activity, and consumer acceptance, confirming the superiority of the developed polyherbal anti-acne face wash.

Table 9: Comparative Evaluation of Developed and Marketed Anti-Acne Face Wash.

Parameter	Developed Face Wash (F6)	Marketed Face Wash
Appearance	Smooth, homogeneous, translucent green gel	Slightly opaque gel
pH	5.82 ± 0.02	6.18 ± 0.03
Viscosity (cP)	2185 ± 24	1980 ± 20
Spreadability (g·cm/sec)	8.6 ± 0.15	7.8 ± 0.12
Foam Volume (mL)	98 ± 2	86 ± 3

Washability	Excellent	Good
Skin Feel	Smooth, non-drying	Slightly drying
Zone of Inhibition against <i>C. acnes</i> (mm)	21.4 ± 0.8	17.2 ± 0.6
Zone of Inhibition against <i>S. aureus</i> (mm)	19.6 ± 0.7	15.8 ± 0.5
DPPH Antioxidant Activity (%)	82.5 ± 1.2	64.3 ± 1.5
Skin Irritation Score	0.10 ± 0.31	0.35 ± 0.42
Stability after 90 Days	No significant change	Slight viscosity reduction
Consumer Acceptance (%)	94	81
Natural Herbal Content (%)	11.0	4.5
Overall Performance Rating	Excellent	Good

CONCLUSION

The present study successfully developed and evaluated a polyherbal anti-acne face wash containing Neem (*Azadirachta indica*), Tulsi (*Ocimum sanctum*), Liquorice (*Glycyrrhiza glabra*), Turmeric (*Curcuma longa*), Aloe vera, and Tea Tree Oil. The synergistic combination of these medicinal herbs provided multiple therapeutic benefits, including antibacterial, anti-inflammatory, antioxidant, moisturizing, and skin-soothing effects, making the formulation highly suitable for the management of acne-prone skin.

Among the developed formulations, batch F6 was identified as the optimized formulation based on its desirable physicochemical properties, including skin-compatible pH, appropriate viscosity, excellent spreadability, superior foamability, and good washability. The formulation demonstrated significant antimicrobial activity against *Cutibacterium acnes* and *Staphylococcus aureus*, which are major microorganisms associated with acne vulgaris. Furthermore, the DPPH assay confirmed strong antioxidant activity, indicating its potential to reduce oxidative stress and inflammation involved in acne development.

The optimized formulation showed excellent skin compatibility with negligible irritation and maintained its physicochemical stability throughout the accelerated stability study conducted under ICH conditions. Consumer acceptance studies revealed a high satisfaction rate, highlighting the favorable appearance, fragrance, cleansing performance, and overall user experience of the developed product.

Comparative evaluation with a marketed anti-acne face wash demonstrated the superiority of the developed formulation in terms of antibacterial efficacy, antioxidant activity, foamability, skin compatibility, stability, and consumer acceptance. Therefore, the formulated polyherbal

anti-acne face wash can be considered a safe, effective, stable, and economical natural alternative to conventional synthetic anti-acne products. Further clinical studies on a larger population are recommended to establish its long-term therapeutic efficacy and commercial potential.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this research article. The authors alone are responsible for the content and writing of this manuscript.

Author Contributions

Jitendra Pratap Singh conceived and designed the study, performed formulation development and optimization experiments, analyzed the data, interpreted the results, and prepared the original manuscript draft.

Rishabh Maurya contributed to the experimental work, characterization studies, data collection, statistical analysis, and literature review.

Tanushree Agnihotri supervised the research work, provided scientific guidance, reviewed and edited the manuscript, and contributed to data interpretation and final approval of the manuscript.

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