RESEARCH PAPER

FORMULATION AND EVALUATION OF HERBAL ANTI-ACNE GEL: INCORPORATING ALEO VERA, TURMERIC EXTRACT AND *PONGAMIA PINNATA* SEED EXTRACT

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Abstract
The present study was aimed at the formulation and evaluation of a polyherbal anti-acne gel containing hydroalcoholic extracts of *Curcuma longa* and *Pongamia pinnata* incorporated with *Aloe vera* gel for topical application. The hydroalcoholic extracts were prepared and evaluated for percentage yield and preliminary phytochemical screening. The extracts showed the presence of important phytoconstituents including flavonoids, phenolic compounds, alkaloids, glycosides, diterpenes, and saponins. Total phenolic and flavonoid contents of the extracts were also estimated. Six gel formulations (HG1–HG6) were prepared using varying concentrations of plant extracts and Carbopol 940 as the gelling agent. The prepared formulations were evaluated for physical appearance, homogeneity, spreadability, washability, extrudability, pH, viscosity, flavonoid content, and anti-acne activity. Among all formulations, HG5 showed optimum physicochemical properties with excellent homogeneity, smooth texture, satisfactory spreadability, suitable pH, acceptable viscosity, and highest flavonoid content. The antimicrobial activity of the optimized formulation was evaluated against *Propionibacterium acnes* using the agar well diffusion method. The optimized herbal gel exhibited significant concentration-dependent anti-acne activity, although lower than standard clindamycin. The study concluded that the developed polyherbal anti-acne gel possesses promising physicochemical characteristics and antimicrobial potential, suggesting its suitability as a safe and effective topical herbal formulation for the management of acne vulgaris.

Keywords: Polyherbal gel; Acne vulgaris; *Curcuma longa*; *Pongamia pinnata*; *Aloe vera*; Antimicrobial activity; Topical drug delivery; Herbal formulation; Flavonoids; Carbopol 940.
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Introduction

Acne vulgaris is one of the most common chronic inflammatory disorders of the pilosebaceous unit, affecting adolescents and adults worldwide. It is characterized by the formation of comedones, papules, pustules, nodules, and in severe cases, cystic lesions that may lead to permanent scarring and psychological distress (Alsaadoon et al., 2024). The pathogenesis of acne involves multiple factors including excessive sebum production, follicular hyperkeratinization, colonization of *Cutibacterium acnes* (formerly *Propionibacterium acnes*), inflammation, oxidative stress, and hormonal imbalance (Mawardi et al., 2021). Conventional therapies such as topical antibiotics, retinoids, benzoyl peroxide, and hormonal agents are widely used for acne management; however, prolonged use of these agents is often associated with adverse effects including skin irritation, dryness, erythema, microbial resistance, and recurrence of lesions. Therefore, there is an increasing demand for safer and more effective alternative therapies derived from natural sources (Shalita, 2001).

Herbal formulations have gained considerable attention in recent years due to their therapeutic efficacy, biocompatibility, lower incidence of side effects, and patient acceptability. Medicinal plants are rich sources of phytoconstituents such as flavonoids, alkaloids, tannins, phenolic compounds, terpenoids, and glycosides, which possess antimicrobial, anti-inflammatory, antioxidant, wound healing, and sebum-regulating activities beneficial in the treatment of acne vulgaris (Saraf, 2010). Among various herbal preparations, topical gels are preferred because of their non-greasy nature, ease of application, enhanced drug release, and improved patient compliance.

Aloe vera is a well-known medicinal plant extensively used in dermatological and cosmetic preparations due to its soothing, moisturizing, anti-inflammatory, antimicrobial, and wound healing properties. Aloe vera gel contains bioactive constituents including polysaccharides, vitamins,

enzymes, amino acids, and phenolic compounds that promote skin hydration and tissue repair while reducing inflammation associated with acne lesions (Saleem et al., 2022).

Curcuma longa (turmeric) is widely recognized for its potent anti-inflammatory, antioxidant, and antimicrobial activities primarily attributed to curcuminoids such as curcumin. Turmeric extract has demonstrated inhibitory activity against acne-causing microorganisms and helps reduce redness, swelling, and oxidative damage associated with inflammatory acne (Khatun et al., 2021).

Pongamia pinnata is another important medicinal plant traditionally used for the treatment of skin disorders, infections, wounds, and inflammatory conditions. The seed extract contains flavonoids, karanjin, pongamol, tannins, and fixed oils exhibiting significant antibacterial, antifungal, antioxidant, and anti-inflammatory activities, making it a promising candidate for anti-acne formulations (Fugare et al., 2021).

The incorporation of these herbal extracts into a topical gel formulation may provide synergistic therapeutic effects against acne vulgaris by targeting microbial growth, inflammation, oxidative stress, and skin healing simultaneously. Therefore, the present study was undertaken to formulate and evaluate herbal anti-acne gel incorporating Aloe vera, turmeric extract, and Pongamia pinnata seed extract. The prepared formulations were evaluated for physicochemical parameters, stability, spreadability, pH, viscosity, antimicrobial activity, and overall suitability for topical anti-acne therapy.

Material and Methods

Material

The materials used in the present study included hydroalcoholic extracts of Curcuma longa and Pongamia pinnata, along with Aloe vera gel as the major herbal ingredients for formulation of the anti-acne gel. Carbopol 940 was used as the gelling agent, while polyethylene glycol and glycerin were incorporated as humectants and stabilizing agents. Methyl paraben and propyl paraben were used as preservatives, and triethanolamine was added for pH adjustment and gel neutralization. Distilled water was used as the vehicle for preparation of the formulations.

Methods

Preparation of aloe gel solution

Fresh *Aloe vera* leaves were collected from the plant and washed thoroughly under running tap water, followed by rinsing with sterile distilled water. The leaves were then cut carefully, and the thick outer epidermal layer was selectively removed using a sterile knife. The gel-like pulp was separated using a spoon and homogenized using a mixer to obtain a uniform gel preparation.

Extraction by maceration process

Extraction is an essential step in phytochemical processing for the finding of bioactive secondary metabolite from plant materials (Pradhan *et al.,* 2010). Extraction is used in the removal of desirable soluble constituents, exclusion those not required with the help of the selected solvents. 50 gram of Rhizomes of *Curcuma longa* and seeds of *Pongamia pinnata* shade dried plant material were coarsely powdered and subjected to extraction by maceration method. Rhizomes of *Curcuma longa* and seeds of *Pongamia pinnata* were exhaustively extracted with hydroalcoholic solvent (Methanol: Aqueous; 70:30v/v) by maceration method. The extract was evaporated above their boiling points. Finally, the percentage yields were calculated of the dried extracts (Ansari, 2001; Mukherjee, 2007).

Determination of percentage yield

The extraction yield is evaluate of the solvent's efficiency to extracts bioactive components from the selected natural plant samples and it was defined as quantity of plant extracts recovered in mass after solvent extraction compared with the initial quantity of plant samples. After extraction, yield of the plant extracts obtained were calculated in grams and then converted it into percentage. The percentage yield of each extract was calculated by using following formula:

$$\textbf{Percentage Yield} = \frac{Weight\ of\ Extract}{Weight\ of\ Powder\ drug\ taken} x\ 100$$

Phytochemical screening

Medicinal plants are resources of traditional medicines and many of the modern medicines are produced indirectly from plants. Phytochemical constituents are of two type primary bioactive constituents (Chlorophyll, proteins, amino acids, sugar etc.) and secondary bioactive constituents include (Alkaloids, terpenoids, phenols, flavonoids etc.). Phytochemical examinations were carried out for all the extracts as per the standard methods (Khandelwal, 2005; Kokate, 1994).

Quantitative estimation of bioactive compounds

Total phenolic content estimation

The total phenolic content of the extract was determined by the modified folin-ciocalteu method. 10 mg Gallic acid was dissolved in 10 ml methanol, various aliquots of 10-50µg/ml was prepared in methanol. 10 mg of dried extract was dissolved in 10 ml methanol and filter. Two ml (1mg/ml) of this extract was for the estimation of phenol. 2 ml of extract and each standard was mixed with 1 ml of folin-ciocalteu reagent (previously diluted with distilled water 1:10 v/v) and 1 ml (7.5g/L) of sodium

carbonate. The mixture was vortexed for 15s and allowed to stand for 10min for colour development. The absorbance was measured at 765 nm using a spectrophotometer (Parkhe and Bharti, 2019).

Total flavonoids content estimation

Determination of total flavonoids content was based on aluminium chloride method. 10 mg quercetin was dissolved in 10 ml methanol, and various aliquots of 5-25µg/ml were prepared in methanol. 10 mg of dried extract was dissolved in 10 ml methanol and filter. Three ml (1mg/ml) of this extract was for the estimation of flavonoids. 1 ml of 2% $AlCl_3$ solution was added to 3 ml of extract or each standard and allowed to stand for 15min at room temperature; absorbance was measured at 420 nm (Parkhe and Bharti, 2019).

Formulation development of anti acne herbal gel

Herbal gel formulations (HG1–HG6) containing *Aloe barbadensis* gel, *Curcuma longa* extract, and *Pongamia pinnata* extract were prepared using varying concentrations of Carbopol 940 as a gelling agent according to the modified method of Nand et al. (2012).

Initially, accurately weighed quantities of *Curcuma longa* extract and *Pongamia pinnata* extract were dissolved in a small quantity of distilled water containing polyethylene glycol and glycerin with continuous stirring to obtain a uniform dispersion. Methyl paraben and propyl paraben were added as preservatives and mixed thoroughly until completely dissolved. *Aloe barbadensis* gel was then incorporated slowly into the above mixture with continuous stirring using a mechanical stirrer to ensure uniform distribution of all ingredients.

Separately, Carbopol 940 was dispersed gradually in approximately 35 mL of distilled water with constant stirring to avoid formation of lumps and allowed to hydrate completely. Different concentrations of Carbopol 940 were used for formulations HG1–HG6 as shown in Table 6.3.

The previously prepared herbal extract mixture was then added slowly to the hydrated Carbopol dispersion under continuous stirring to obtain a homogeneous preparation. Finally, triethanolamine was added dropwise with constant stirring for neutralization and gel formation. The pH was adjusted until a smooth, transparent, and uniform gel consistency was obtained. The final volume of each formulation was adjusted to 100 mL using distilled water. The prepared herbal gel formulations were filled into suitable airtight containers and stored at room temperature for further evaluation studies.

Table 1: Formulation of herbal gel

Ingredients	HG 1	HG 2	HG 3	HG 4	HG 5	HG 6
Aloe barbadensis gel	1 g	1 g	1 g	1 g	1 g	1 g
Curcuma longa extract	0.5 g	0.75 g	1.0 g	1.0 g	1.25 g	1.5 g
Pongamia pinnata extract	0.5 g	0.75 g	1.0 g	1.0 g	1.25 g	1.5 g
Carbopol 940	0.25 g	0.50 g	0.75 g	1.0 g	1.25 g	1.5 g
Polyethylene glycol	0.2 mL	0.2 mL	0.3 mL	0.3 mL	0.4 mL	0.4 mL
Glycerin	0.5 mL	0.5 mL	0.75 mL	0.75 mL	1.0 mL	1.0 mL
Methyl paraben	0.08 g	0.08 g	0.08 g	0.08 g	0.08 g	0.08 g
Propyl paraben	0.02 g	0.02 g	0.02 g	0.02 g	0.02 g	0.02 g
Triethanolamine	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Distilled water	q.s. to 100 mL	q.s. to 100 mL	q.s. to 100 mL	q.s. to 100 mL	q.s. to 100 mL	q.s. to 100 mL

***HG= Herbal gel**

Evaluation of herbal gel

Appearance and consistency

The physical appearance was visually checked for the texture of herbal gel formulations for color, odor and texture (Bhalani and Shah, 2015).

Washability

Formulations were applied on the skin and then ease and extent of washing with water were checked manually.

Extrudability determination of formulations

The herbal gel formulations were filled into collapsible metal tubes or aluminium collapsible tubes. The tubes were pressed to extrude the material and the extrudability of the formulation was checked (Yamini and Onesimus, 2013).

Determination of Spreadability

Two glass slides of standard dimensions (6×2) were selected. The gel formulation whose spreadability had to be determined was placed over one of the slides. The second slide was placed over the slide in such a way that the formulation was sandwiched between them across a length of 6 cms along the slide. 100 grams of weight was placed up on the upper slide so that the gel formulation between the two slides was traced uniformly to form a thin layer. The weight was removed and the excess of the gel formulation adhering to the slides was scrapped off. The lower slide was fixed on the board of the

apparatus and one end of the upper slide was tied to a string to which 20 gram load could be applied 50with the help of a simple pulley. The time taken for the upper slide to travel the distance of 6 cms and separate away from lower slide under the direction of the weight was noted. The experiment was repeated and the average of 6 such determinations was calculated for each gel formulation.

$$\text{Spreadability} = \frac{m.l}{t}$$

Where, S=Spreadability (gcm/sec)
m = weight tied to the upper slide (20 grams)
l= length of glass slide (6cms).
t = time taken is seconds.

Determination of pH

The pH of the gels was determined by digital pH meter. Electrode was dipped in to gel formulation until constant reading obtained. And constant reading was noted. The measurements of pH of each formulation were replicated two times (Bhaskar *et al.,* 2009).

Drug content

Flavonoids content

The drug content was determined by taking 1gm of gel in 10 ml volumetric flask diluted with methanol. 3 ml of stock solution was mixed with 1 ml of 2% $AlCl_3$ solution. The mixture was vortexed for 15s and allowed to stand for 10min for colour development. The absorbance was measured at 420 nm using a spectrophotometer.

***In vitro* antiacne activity of herbal gel**

The well diffusion method was used to determine the antiacne activity of the herbal gel prepared using standard procedure. There were 3 concentration used which are 25, 50 and 100 mg/ml for studies. The plates were incubated at 24 hours at 37^{o}C and then examined for clear zones of inhibition around the wells with particular concentration of drug.

Results and Discussion

The present study was undertaken to formulate and evaluate a polyherbal anti-acne gel containing hydroalcoholic extracts of Curcuma longa and Pongamia pinnata incorporated with Aloe vera gel for topical anti-acne therapy. Herbal medicines have gained considerable importance in dermatological applications because of their safety, therapeutic efficacy, and reduced adverse effects compared with conventional synthetic agents. The developed formulations were evaluated for physicochemical properties, phytochemical constituents, and antimicrobial activity against acne-causing microorganisms.

The hydroalcoholic extraction process yielded appreciable quantities of plant extracts, with *Curcuma longa* showing a percentage yield of 8.25% and *Pongamia pinnata* showing 6.90%, as presented in Table 2. The higher extraction yield of *Curcuma longa* may be attributed to the presence of greater amounts of soluble phytoconstituents such as curcuminoids, phenolics, and flavonoids in the hydroalcoholic solvent system. Hydroalcoholic solvents are known to efficiently extract both polar and moderately non-polar bioactive compounds from medicinal plants.

Preliminary phytochemical screening revealed the presence of several important secondary metabolites in both plant extracts (Table 3 and Table 4). The hydroalcoholic extract of *Curcuma longa* showed positive tests for alkaloids, flavonoids, phenolic compounds, proteins, and diterpenes, whereas *Pongamia pinnata* extract exhibited glycosides, flavonoids, saponins, phenolic compounds, carbohydrates, and diterpenes. The presence of flavonoids and phenolic compounds in both extracts suggests significant antioxidant and anti-inflammatory potential, which may contribute to acne management by reducing oxidative stress and inflammation associated with acne lesions. Similarly, diterpenes and glycosides are reported to possess antimicrobial and wound healing properties beneficial for topical therapy.

Quantitative estimation of phytoconstituents demonstrated that *Pongamia pinnata* possessed higher total phenolic content (0.59 mg/100 mg of dried extract) compared with *Curcuma longa* (0.12 mg/100 mg), whereas *Curcuma longa* showed comparatively higher flavonoid content (0.85 mg/100 mg) than *Pongamia pinnata* (0.70 mg/100 mg), as shown in Table 5. Phenolic and flavonoid compounds are well known for their antioxidant and antimicrobial activities, which are considered important in preventing microbial colonization and inflammatory responses during acne pathogenesis.

Six gel formulations (HG1–HG6) were prepared using varying concentrations of plant extracts and Carbopol 940 as the gelling agent, as described in Table 1. The prepared formulations were evaluated for physical appearance including color, homogeneity, texture, and clogging characteristics (Table 5). Among all formulations, HG5 exhibited the best overall appearance with excellent homogeneity, smooth glossy texture, and absence of clogging, indicating uniform distribution of herbal extracts within the gel matrix. In contrast, HG6 showed slight clogging and thicker consistency,

probably due to the higher concentration of Carbopol and plant extracts.

Washability and extrudability studies demonstrated that the prepared formulations possessed acceptable topical application properties (Table 7). HG5 showed excellent washability and extrudability, indicating ease of removal from skin and satisfactory release from collapsible tubes. These properties are important for patient compliance and convenient topical administration.

The spreadability values of the formulations ranged from 16.3±2 to 28.6±2 g·cm/sec, as shown in Table 8. Spreadability decreased with increasing polymer concentration due to increased viscosity of the gel system. HG5 demonstrated satisfactory spreadability (18.4±2 g·cm/sec), allowing easy application over the skin surface while maintaining sufficient consistency for prolonged retention at the site of application.

The pH values of the developed gels ranged between 5.9±0.6 and 7.2±0.4, except HG4 which exhibited a slightly alkaline pH of 8.5±0.1 (Table 8). Most formulations showed pH values close to normal skin pH, indicating suitability for topical application without causing significant irritation. The viscosity of formulations ranged from 2017±12 to 3015±10 cps. Increased Carbopol concentration contributed to increased viscosity and gel consistency. HG5 showed optimum viscosity (2017±12 cps), providing suitable consistency and ease of application.

Flavonoid content analysis demonstrated effective incorporation of phytoconstituents within the gel formulations (Table 8). Among all formulations, HG5 exhibited the highest flavonoid content (84±0.5%), indicating better retention and uniform distribution of herbal actives within the gel base. This may contribute to enhanced therapeutic effectiveness of the formulation.

The anti-acne activity of optimized formulation HG5 was evaluated against *Propionibacterium acnes* and compared with standard clindamycin (Table 9). The optimized gel exhibited concentration-dependent antimicrobial activity with zones of inhibition measuring 9±0.57 mm, 12±0 mm, and 15±0.47 mm at concentrations of 25, 50, and 100 mg/mL respectively. Although the activity was comparatively lower than standard clindamycin, the formulation demonstrated significant antibacterial potential against acne-causing bacteria. The antimicrobial activity may be attributed to the synergistic action of curcuminoids, flavonoids, phenolics, terpenoids, and other phytoconstituents present in the herbal extracts.

The findings of the present investigation suggest that the polyherbal anti-acne gel formulation possesses desirable physicochemical characteristics, good stability, satisfactory topical applicability, and promising antimicrobial activity. Among all formulations, HG5 was identified as the optimized formulation based on its excellent physical properties, appropriate pH, satisfactory viscosity, high flavonoid content, and significant anti-acne activity. The study supports the potential use of herbal gel formulations containing *Curcuma longa*, *Pongamia pinnata*, and Aloe vera for safe and effective management of acne vulgaris.

Table 2: Results of percentage yield of extract of *Curcuma longa* and *Pongamia pinnata*

S. No.	Hydroalcoholic extracts	Percentage yield (w/w)
1	*Curcuma longa*	8.25%
2	*Pongamia pinnata*	6.90%

Table 3: Result of phytochemical screening of extract of *Curcuma longa*

S. No.	Constituents	Hydroalcoholic extract
1.	Alkaloids A) Wagner's Test: B) Hager's Test:	 +Ve -Ve
2.	Glycosides A) Legal's Test:	 -Ve
3.	Flavonoids A) Lead acetate Test: B) Alkaline Reagent Test:	 +Ve +Ve
4.	Saponins A) Froth Test:	 -Ve
5.	Phenol A) Ferric Chloride Test: B) FC reagent test:	 -Ve +Ve
6.	Proteins A) Xanthoproteic Test:	 +Ve
7.	Carbohydrate A) Fehling's Test: B) Benedict test:	 -Ve -Ve
8.	Diterpenes A) Copper acetate Test:	 +Ve
9.	Sterols	-Ve
10.	Tannins A) Gelatin test:	 -Ve

Table 4: Result of phytochemical screening of extract of *Pongamia pinnata*

S. No.	Constituents	Hydroalcoholic extract
1.	Alkaloids A) Wagner's Test: B) Hager's Test:	 -Ve -Ve
2.	Glycosides A) Legal's Test:	 +Ve
3.	Flavonoids A) Lead acetate Test: B) Alkaline Reagent Test:	 +Ve +Ve
4.	Saponins A) Froth Test:	 +Ve
5.	Phenol A) Ferric Chloride Test: B) FC reagent test:	 +Ve +Ve
6.	Proteins A) Xanthoproteic Test:	 -Ve
7.	Carbohydrate A) Fehling's Test: B) Benedict test:	 +Ve +Ve
8.	Diterpenes A) Copper acetate Test:	 +Ve
9.	Sterols	-Ve
10.	Tannins A) Gelatin test:	 -Ve

Table 5: Estimation of total phenolic and flavonoids content of *Curcuma longa* and *Pongamia pinnata*

S. No.	Hydroalcoholic extract	Total phenol content (mg/100mg of dried extract)	Total flavonoids content (mg/ 100 mg of dried extract)
1.	*Curcuma longa*	0.12	0.85
2.	*Pongamia pinnata*	0.59	0.70

Table 6: Results of physical appearance

Formulation	Colour	Clogging	Homogeneity	Texture
HG1	Light brown	Absent	Fair	Slightly smooth
HG2	Brown	Absent	Good	Smooth
HG3	Brown	Absent	Good	Smooth
HG4	Dark brown	Absent	Very good	Smooth and uniform
HG5	Dark brown	Absent	Excellent	Smooth and glossy
HG6	Dark brown	Slightly present	Good	Slightly thick

Table 7: Results of washability and Extrudability

Formulation	Washability	Extrudability
HG1	Good	Fair
HG2	Good	Average
HG3	Very good	Good
HG4	Very good	Good
HG5	Excellent	Excellent
HG6	Good	Moderate

Table 8: Results of spreadability

Formulation Code	Spreadability (g·cm/sec)	Determination of pH	Viscosity (cps)	Flavonoids content (%)
HG1	28.6 ± 2	6.4±0.2	3015±10	70±0.1
HG2	26.3 ± 3	6.2±0.5	2874±08	75±0.3
HG3	24.4 ± 2	5.9±0.6	2569±15	73±0.7
HG4	21.6 ± 3	8.5±0.1	2274±03	80±0.2
HG5	18.4 ± 2	6.8±0.3	2017±12	84±0.5
HG6	16.3 ± 2	7.2±0.4	2153±20	78±0.3

***Mean±S.D., Average of three determinations**

Table 9: Antiacne activity of Clindamycin and optimized herbal gel formulation (HG5) against *Propionibacterium acnes*

S. No.	Standard / Formulation	Zone of inhibition (mm)		
		10µg/ml	20 µg/ml	30 µg/ml
1.	Clindamycin	13±0.94	17±0.57	20±0.86
2.	HG5	**25mg/ml**	**50mg/ml**	**100mg/ml**
		9±0.57	12±0	15±0.47

Conclusion

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