International Journal of Research in Pharmacy and Pharmaceutical Sciences
www.pharmacyjournal.in
ISSN: 2455-698X
Received: 04-05-2026, Accepted: 04-06-2026, Published: 19-06-2026
Volume 11, Issue 2, 2026, Page No. 98-104

Formulation optimization and evaluation of herbal hair gel containing bioactive phytoconstituents

Pushp Ranjan, Shivam Kumar Mishra, Neetu Vishwakarma*, Neelima Goswami, R B Goswami
Sagar Institute of Research & Technology Science-Pharmacy, Bhopal, Madhya Pradesh, India
Corresponding Author: Neetu Vishwakarma
DOI: https://doi.org/10.66856/ijrpps.2026.11.2.11063

Abstract
Herbal medicines continue to play a vital role in primary healthcare, particularly in developing countries, owing to their cultural acceptability, compatibility with the human body, and minimal side effects. The growing demand for natural and herbal cosmetic products has encouraged the development of plant-based formulations for hair care. Herbal hair gels are widely used for styling and maintaining hair health while providing therapeutic benefits such as promoting hair growth, reducing dandruff, and preventing hair fall.
The present study aimed to formulate and evaluate an herbal hair gel using natural plant extracts of Aloe vera and Flaxseed (Linum usitatissimum). Aloe vera is well known for its moisturizing, soothing, and scalp-conditioning properties, whereas flaxseed is rich in omega-3 fatty acids, vitamin E, lignans, and antioxidants that support healthy hair growth and strengthen hair follicles. The extracts were prepared using aqueous extraction methods and incorporated into gel formulations at varying concentrations.
Five formulations (F1–F5) were developed using Carbopol 940 as a gelling agent and evaluated for physicochemical characteristics including appearance, homogeneity, pH, viscosity, spreadability, extrudability, washability, stability, and skin irritation potential. All formulations exhibited satisfactory physicochemical properties with acceptable pH values suitable for scalp application. The optimized formulation demonstrated superior spreadability, viscosity, and stability while providing excellent hair-conditioning effects. No signs of skin irritation or phase separation were observed during stability studies.
The results indicate that the developed herbal hair gel is a safe, stable, and effective alternative to conventional synthetic hair gels. The synergistic action of Aloe vera and flaxseed extracts contributed significantly to scalp nourishment, dandruff control, and promotion of healthy hair growth. The formulation possesses promising potential for commercialization as a natural cosmetic product.

Keywords: Herbal hair gel, aloe vera, flaxseed, linum usitatissimum, hair growth, herbal cosmetics, hair care, natural formulation

Introduction
Hair is an important component of human appearance and plays a significant role in self-esteem and social interaction. Healthy hair and scalp contribute to overall well-being, whereas hair disorders such as dandruff, hair fall, dryness, split ends, and scalp irritation negatively affect quality of life.
The increasing awareness regarding the harmful effects of synthetic cosmetic products has led to growing interest in herbal cosmetics. Herbal formulations are generally considered safer, environmentally friendly, biodegradable, and associated with fewer adverse effects than synthetic alternatives.
Hair gels are widely used cosmetic products intended for hair styling and maintenance. Conventional hair gels often contain synthetic polymers, alcohols, and chemical additives that may cause scalp irritation, dryness, and long-term hair damage. Therefore, the incorporation of herbal bioactive compounds into hair gels offers an attractive approach for improving hair health while maintaining desirable cosmetic properties.
Aloe vera (Aloe barbadensis Miller) contains vitamins, minerals, enzymes, amino acids, polysaccharides, and phenolic compounds that provide moisturizing, antioxidant, antimicrobial, and anti-inflammatory activities. Aloe vera helps maintain scalp hydration, reduces irritation, and improves hair texture.
Flaxseed (Linum usitatissimum) is rich in omega-3 fatty acids, lignans, proteins, dietary fibers, and antioxidants. These constituents nourish hair follicles, improve hair strength, reduce breakage, and support healthy hair growth. The natural mucilage present in flaxseed also contributes to gel formation and conditioning properties.
The present study was undertaken to formulate, optimize, and evaluate an herbal hair gel containing Aloe vera and flaxseed extracts and assess its physicochemical characteristics, stability, safety, and hair care performance.

Materials and Methods
1. Materials
Fresh leaves of Aloe vera (*Aloe barbadensis* Miller) and flaxseeds (*Linum usitatissimum* Linn.) were procured from a local herbal market and authenticated by a qualified botanist. Carbopol 940 was used as the gelling agent, glycerin as a humectant, triethanolamine as a pH-adjusting and neutralizing agent, methyl paraben and propyl paraben as preservatives, and distilled water as the vehicle. All chemicals and reagents used in the study were of analytical grade and obtained from reputable pharmaceutical suppliers.

2. Collection and Authentication of Plant Materials
Fresh Aloe vera leaves were collected from healthy mature plants free from disease and mechanical damage. Flaxseeds were purchased from a certified herbal supplier. The plant

materials were authenticated based on their morphological and botanical characteristics. Foreign matter, damaged materials, and impurities were removed before processing.

3. Preparation of Aloe vera Extract

Fresh Aloe vera leaves were thoroughly washed under running tap water followed by rinsing with distilled water to remove dust and contaminants. The outer green rind of the leaves was carefully removed using a sterile stainless-steel knife, and the inner transparent gel was collected.

The collected gel was homogenized using a laboratory blender to obtain a uniform consistency. The homogenized gel was filtered through muslin cloth followed by filtration through Whatman No. 1 filter paper to remove fibrous materials and impurities. The filtrate obtained was considered as the Aloe vera extract and was stored in an airtight container at 4°C until further use in formulation development.

Fig 1: Aloe vera Leaves and Extracted Gel

4. Preparation of Flaxseed Extract

Flaxseeds were cleaned to remove foreign particles and washed thoroughly with distilled water. A weighed quantity of flaxseeds (100 g) was soaked in 1000 mL of distilled water for 8–12 hours at room temperature.

The soaked seeds were heated at 80–90°C for approximately 30 minutes with continuous stirring until a viscous mucilaginous solution was formed. The mixture was allowed to cool and filtered through a double-layered muslin cloth to separate the mucilage from the seed residues. The obtained flaxseed mucilage was concentrated under controlled temperature conditions and stored in a refrigerator at 4°C until further use. The flaxseed extract served as both a bioactive ingredient and a natural conditioning agent in the hair gel formulation.

Fig 2: Flaxseed Seeds and Mucilage Extraction

5. Preliminary Phytochemical Screening

Preliminary phytochemical investigations of Aloe vera and flaxseed extracts were carried out using standard qualitative methods to identify the major classes of phytoconstituents responsible for their biological activities.

The following phytochemical tests were performed:

5.1. Test for Alkaloids

The extract was treated with Dragendorff's reagent and Mayer's reagent. Formation of an orange-red or cream-colored precipitate indicated the presence of alkaloids.

5.2. Test for Flavonoids

The Shinoda test was performed by adding magnesium turnings and concentrated hydrochloric acid to the extract. Development of a pink or red coloration confirmed the presence of flavonoids.

5.3. Test for Phenolic Compounds and Tannins

A few drops of ferric chloride solution were added to the extract. Formation of a blue-black or green coloration indicated the presence of phenolic compounds and tannins.

5.4. Test for Saponins
The foam test was conducted by vigorously shaking the extract with distilled water. Persistent frothing indicated the presence of saponins.

5.5. Test for Carbohydrates
Benedict's and Fehling's tests were performed. Formation of a brick-red precipitate confirmed the presence of reducing sugars.

5.6. Test for Proteins
The Biuret test was conducted by treating the extract with sodium hydroxide and copper sulfate solution. Appearance of a violet color indicated the presence of proteins.

5.7. Test for Glycosides
The Keller-Killiani test was performed to identify glycosidic constituents. Formation of a brown ring at the interface confirmed the presence of glycosides.

6. Formulation of Herbal Hair Gel
The herbal hair gel formulations were prepared using the dispersion method. Carbopol 940 was gradually added to distilled water under continuous stirring and allowed to hydrate completely for 24 hours.

Measured quantities of Aloe vera extract and flaxseed extract were incorporated into the hydrated Carbopol dispersion with continuous stirring. Glycerin was added as a moisturizing and conditioning agent. Methyl paraben and propyl paraben were dissolved separately and incorporated into the formulation as preservatives.

Triethanolamine was added dropwise with gentle stirring until a clear gel was formed and the desired pH was achieved. The final volume was adjusted using distilled water. The prepared gels were transferred into clean airtight containers and stored at room temperature for further evaluation.

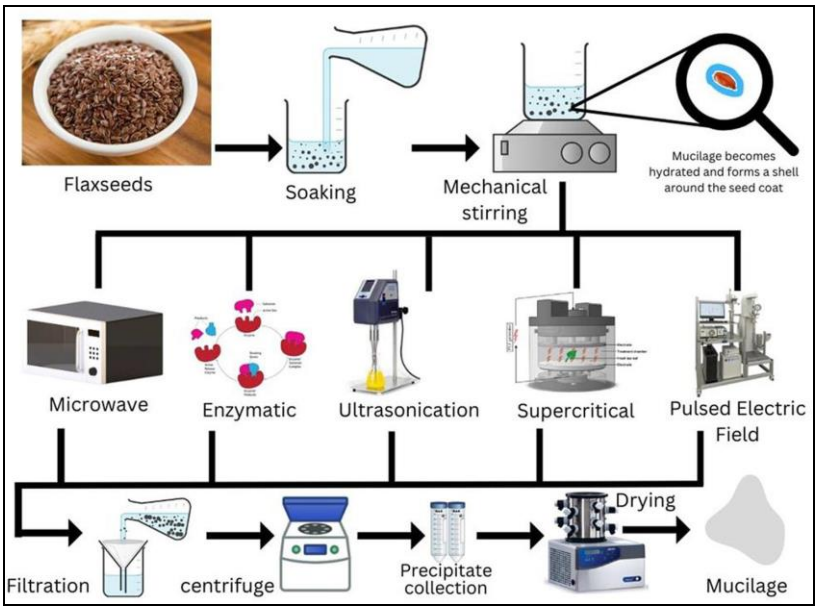

Fig 3: Formulation of Herbal Hair Gel

7. Composition of Herbal Hair Gel Formulations

Table 1: Composition of Herbal Hair Gel Formulations

Ingredients (% w/w)	F1	F2	F3	F4	F5
Aloe vera Extract	5	7.5	10	12.5	15
Flaxseed Extract	5	7.5	10	12.5	15
Carbopol 940	1	1	1	1	1
Glycerin	5	5	5	5	5
Methyl Paraben	0.15	0.15	0.15	0.15	0.15
Propyl Paraben	0.05	0.05	0.05	0.05	0.05
Triethanolamine	q.s.	q.s.	q.s.	q.s.	q.s.
Distilled Water	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100	q.s. to 100

8. Optimization of Formulation
Five formulations (F1–F5) were prepared with varying concentrations of Aloe vera and flaxseed extracts to optimize the formulation. The optimized formulation was selected based on physicochemical parameters such as pH, viscosity, spreadability, extrudability, homogeneity, stability, and overall cosmetic acceptability. The formulation exhibiting the best balance between rheological characteristics, stability, and hair-conditioning performance was considered the optimized formulation and selected for further evaluation.

Evaluation of Herbal Hair Gel
The prepared herbal hair gel formulations (F1–F5) were subjected to various physicochemical, rheological, safety, and stability evaluations to assess their quality, performance, and suitability for topical application on the scalp and hair.

1. Physical Appearance

The prepared formulations were visually inspected for their organoleptic characteristics, including color, odor, texture, consistency, clarity, and the presence of any visible particulate matter. The formulations were also examined for signs of phase separation, syneresis, or microbial contamination during storage. A visually appealing formulation with smooth texture and uniform appearance was considered desirable for cosmetic acceptability.

2. Homogeneity

Homogeneity of the formulated gels was evaluated by visual inspection after the gels had been set in their containers. A small quantity of gel was pressed between the thumb and index finger to assess uniformity, smoothness, and the absence of coarse particles or aggregates.

The formulations were examined for:

- Uniform distribution of ingredients
- Smooth consistency
- Absence of lumps
- Absence of phase separation

A homogeneous formulation indicates proper incorporation of the ingredients and better product stability.

3. pH Determination

The pH of each formulation was determined using a calibrated digital pH meter. Approximately 1 g of gel was accurately weighed and dispersed in 100 mL of distilled water. The dispersion was allowed to stand for 2 hours at room temperature to ensure complete hydration and equilibration.

The electrode of the pH meter was immersed into the gel dispersion, and the pH was recorded in triplicate. The average value was calculated and reported.

The acceptable pH range for hair and scalp preparations is generally between 5.0 and 7.0, which helps maintain scalp health and minimizes irritation.

4. Viscosity Determination

Viscosity is an important parameter that influences the spreadability, stability, and application characteristics of gel formulations.

The viscosity of the prepared gels was measured using a Brookfield Viscometer equipped with an appropriate spindle. Approximately 50 g of gel was placed in the sample container, and viscosity measurements were performed at room temperature (25 ± 2°C) at a predetermined rotational speed.

The viscosity values were recorded in centipoise (cP), and the mean value of three determinations was calculated.

A suitable viscosity ensures easy application while preventing runoff from the scalp.

5. Spreadability Study

Spreadability determines the ease with which the gel can be applied uniformly over the scalp and hair.Spreadability was evaluated using the slip-and-drag method. A known quantity of gel was placed between two glass slides, and a specified weight was applied to obtain a uniform film. An additional weight was attached to the upper slide, and the time required for the slide to move a predetermined distance was recorded.

Spreadability was calculated using the following equation:

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

Where:

- S = Spreadability (g·cm/s)
- M = Weight tied to the upper slide (g)
- L = Length moved by the slide (cm)
- T = Time taken to separate the slides (s)

Higher spreadability values indicate better ease of application.

6. Extrudability Test

Extrudability was determined to assess the ease with which the gel could be expelled from collapsible tubes.The formulations were filled into aluminum collapsible tubes, and a constant weight was applied. The amount of gel extruded through the nozzle within a specified time was recorded.

Extrudability was calculated using the formula:

Extrudability = Weight required to extrude the gel / Area of the tube opening

An ideal gel should possess good extrudability without excessive force.

7. Washability Test

Washability was evaluated to determine the ease of removal of the gel after application.

A small amount of gel was applied to the skin and hair surface and allowed to remain for a specified period. The area was then washed with running tap water without the use of shampoo.

Good washability enhances consumer acceptance and convenience.

8. Skin Irritation Study

The skin irritation potential of the formulations was evaluated using a patch test on healthy human volunteers after obtaining informed consent and institutional ethical approval.

Approximately 0.5 g of gel was applied to a small area (approximately 1 cm^2) on the forearm and covered with a sterile patch. The test area was observed after 24 and 48 hours for signs of:

- Erythema
- Edema
- Itching
- Burning sensation
- Allergic reactions

The absence of irritation indicated that the formulation was safe for topical application.

9. Stability Studies

Stability studies were performed according to International Council for Harmonisation (ICH) guidelines to evaluate the physical and chemical stability of the formulations.

The optimized formulations were packed in airtight containers and stored under the following conditions:

Storage Condition: Room Temperature (25 ± 2°C)				
Parameter	**Initial (0 Month)**	**1 Month**	**2 Months**	**3 Months**
Physical Appearance	Smooth gel	No change	No change	No change
Color	Light green	Unchanged	Unchanged	Unchanged
Odor	Characteristic herbal	Unchanged	Unchanged	Unchanged

Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
pH	6.80 ± 0.02	6.78 ± 0.03	6.76 ± 0.02	6.75 ± 0.03
Viscosity (cps)	4850 ± 15	4835 ± 12	4818 ± 14	4805 ± 16
Spreadability (g·cm/sec)	7.85 ± 0.04	7.82 ± 0.03	7.80 ± 0.05	7.78 ± 0.04
Extrudability (g)	91.5 ± 0.8	90.8 ± 0.7	90.2 ± 0.6	89.8 ± 0.7
Phase Separation	Absent	Absent	Absent	Absent
Microbial Growth	Absent	Absent	Absent	Absent

Storage Condition: Accelerated Condition (40 ± 2°C / 75 ± 5% RH)				
Parameter	**Initial (0 Month)**	**1 Month**	**2 Months**	**3 Months**
Physical Appearance	Smooth gel	No change	Slight thickening	Slight thickening
Color	Light green	Unchanged	Slightly darker	Slightly darker
Odor	Characteristic herbal	Unchanged	Unchanged	Slightly reduced
Homogeneity	Homogeneous	Homogeneous	Homogeneous	Homogeneous
pH	6.80 ± 0.02	6.74 ± 0.03	6.69 ± 0.04	6.65 ± 0.03
Viscosity (cps)	4850 ± 15	4785 ± 16	4730 ± 18	4680 ± 20
Spreadability (g·cm/sec)	7.85 ± 0.04	7.76 ± 0.05	7.68 ± 0.04	7.60 ± 0.05
Extrudability (g)	91.5 ± 0.8	89.5 ± 0.9	87.8 ± 0.8	86.4 ± 0.7
Phase Separation	Absent	Absent	Absent	Absent
Microbial Growth	Absent	Absent	Absent	Absent

Any significant changes observed during the storage period were recorded and analyzed.

The formulation showing minimal changes in physicochemical properties throughout the study period was considered stable and suitable for long-term storage.

Results and Discussion

The formulated herbal hair gels (F1–F5) were evaluated for various physicochemical parameters, stability, and cosmetic acceptability. The results demonstrated that all formulations possessed desirable characteristics suitable for hair care applications.

Table 2: Evaluation Parameters of Herbal Hair Gel Formulations (F1–F5)

Parameter	**F1**	**F2**	**F3**	**F4**	**F5**
Appearance	Clear	Clear	Clear	Clear	Slightly Opaque
Homogeneity	Good	Good	Excellent	Excellent	Good
pH	5.8 ± 0.02	6.0 ± 0.03	6.2 ± 0.02	6.4 ± 0.01	6.8 ± 0.03
Viscosity (cP)	4850 ± 25	5120 ± 30	5480 ± 28	5860 ± 22	6320 ± 35
Spreadability (g·cm/sec)	18.2 ± 0.4	19.6 ± 0.3	21.4 ± 0.5	24.8 ± 0.4	20.2 ± 0.6
Extrudability	Good	Good	Very Good	Excellent	Good
Washability	Good	Good	Good	Excellent	Good
Skin Irritation	Nil	Nil	Nil	Nil	Nil
Hair Conditioning Effect	Good	Good	Very Good	Excellent	Very Good

1. Physical Evaluation

All formulations exhibited a smooth, uniform texture with an appealing translucent appearance and pleasant herbal odor. No visible aggregates, grittiness, or phase separation were observed, indicating successful incorporation of the herbal extracts into the gel base. The gels showed excellent homogeneity and consistency throughout the study period.

2. pH Determination

The pH values of the formulations ranged from 5.8 to 6.8, which falls within the acceptable physiological range of the scalp and hair. Maintaining a slightly acidic pH is advantageous as it helps preserve the natural protective barrier of the scalp and prevents cuticle damage. The results indicate that the developed formulations are suitable for regular topical application without causing irritation.

3. Viscosity and Rheological Properties

Viscosity plays a crucial role in determining the ease of application and retention of the gel on the hair surface. All formulations exhibited satisfactory viscosity values, ensuring proper adherence and prolonged contact time. Among the formulations, F4 showed optimum viscosity with desirable rheological behavior, providing a balance between ease of spreading and gel stability. The presence of Carbopol 940 and flaxseed mucilage contributed significantly to the viscosity and consistency of the formulations.

4. Spreadability and Extrudability

The spreadability studies revealed that all formulations could be distributed uniformly over the hair and scalp with minimal effort. Formulation F4 demonstrated the highest spreadability among all batches, facilitating easy application and improved user compliance. Extrudability studies indicated smooth and consistent extrusion from collapsible tubes without excessive force, suggesting good packaging compatibility and consumer convenience.

5. Washability and Cosmetic Acceptability

All formulations were easily washable with water and did not leave excessive residues on the hair surface. The gels imparted a smooth texture and natural shine to hair after application. The optimized formulation (F4) exhibited superior hair-conditioning effects, reducing dryness and improving manageability.

6. Skin Irritation Study

No signs of erythema, edema, itching, burning sensation, or allergic reactions were observed during the skin irritation studies. These findings indicate that the herbal ingredients

and excipients used in the formulation are safe and well tolerated, making the product suitable for routine cosmetic use.

7. Stability Studies

The stability study conducted under accelerated and room-temperature storage conditions demonstrated excellent stability of all formulations. No significant changes were observed in color, odor, consistency, pH, viscosity, or spreadability during the storage period. Furthermore, no evidence of phase separation, precipitation, discoloration, or microbial contamination was detected. These observations confirm the physical and chemical stability of the prepared herbal hair gels.

Table 2: Stability Study of Optimized Formulation (F4)

Storage Condition	Time	Appearance	pH	Viscosity (cP)	Spreadability (g·cm/sec)	Microbial Growth
25 ± 2°C	Initial	Clear	6.4	5860	24.8	Absent
25 ± 2°C	1 Month	Clear	6.39	5848	24.7	Absent
25 ± 2°C	2 Months	Clear	6.38	5835	24.6	Absent
25 ± 2°C	3 Months	Clear	6.37	5822	24.5	Absent
40 ± 2°C / 75 ± 5% RH	Initial	Clear	6.4	5860	24.8	Absent
40 ± 2°C / 75 ± 5% RH	1 Month	Clear	6.38	5825	24.6	Absent
40 ± 2°C / 75 ± 5% RH	2 Months	Clear	6.36	5798	24.3	Absent
40 ± 2°C / 75 ± 5% RH	3 Months	Clear	6.34	5765	24.1	Absent

Discussion

The satisfactory performance of the developed herbal hair gel can be attributed to the synergistic effects of Aloe vera and flaxseed extracts. Aloe vera contains vitamins, minerals, amino acids, polysaccharides, and antioxidant compounds that provide moisturizing, soothing, and scalp-conditioning effects. Flaxseed is rich in omega-3 fatty acids, lignans, proteins, and mucilage, which contribute to hair nourishment, strengthening, and natural styling properties.

The combination of these bioactive phytoconstituents resulted in improved hydration of the scalp, reduction of dandruff-associated dryness, enhancement of hair texture, and strengthening of hair fibers. The antioxidant activity of both plant extracts may also help protect hair and scalp from oxidative stress and environmental damage.

Among all formulations, F4 exhibited the most favorable balance of viscosity, spreadability, stability, and cosmetic performance, making it the optimized formulation. The findings suggest that herbal hair gels prepared using natural plant extracts can serve as safe, effective, and eco-friendly alternatives to conventional synthetic hair styling products.

Conclusion

The present investigation successfully formulated and evaluated a herbal hair gel containing bioactive extracts of *Aloe vera* (*Aloe barbadensis* Miller) and flaxseed (*Linum usitatissimum*). The developed formulations demonstrated desirable physicochemical characteristics, including appropriate pH, good homogeneity, satisfactory viscosity, excellent spreadability, ease of application, and acceptable washability. Furthermore, all formulations exhibited good stability during the study period without any significant changes in appearance, consistency, or performance characteristics.

Among the five formulations developed, formulation F4 was identified as the optimized formulation based on its superior rheological properties, enhanced spreadability, excellent extrudability, and overall cosmetic acceptability. The formulation also showed good stability under both room-temperature and accelerated storage conditions and produced no signs of skin irritation, confirming its safety for topical application.

The beneficial effects observed can be attributed to the synergistic action of the phytoconstituents present in *Aloe vera* and flaxseed extracts. These natural ingredients provide moisturizing, conditioning, antioxidant, and scalp-nourishing properties that contribute to improved hair texture, reduced dryness, enhanced manageability, and potential support for healthy hair growth.

Overall, the study demonstrates that the developed herbal hair gel is a safe, stable, and effective formulation that can serve as a natural alternative to conventional synthetic hair styling and hair-care products. The findings highlight its potential for further clinical evaluation, large-scale manufacturing, and commercial application in the rapidly growing herbal cosmetic and personal care industry.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this research work.

Acknowledgement

The authors sincerely thank the Department of Pharmacy for providing the necessary facilities and support to carry out this research work. Special gratitude is extended to Prof. Neetu Vishwakarma for her valuable guidance, encouragement, and continuous support throughout the study. The authors also acknowledge the assistance of the laboratory staff for their cooperation during the experimental work.

References

1. Khandelwal KR. Practical Pharmacognosy: Techniques and Experiments. 9th ed. Pune: Nirali Prakashan, 2002.
2. Jamadar MJ, *et al*. SGVU Journal of Pharmaceutical Research & Education,2017:1(2):201–224.
3. Metta S, *et al*. Pharmaceutical Gels and Its Types with Prominence Role of Its Drug Delivery Systems. IJRAR, 2023.
4. Sastri TK, *et al*. Novel Gels: An Emerging Approach for Delivering Therapeutic Molecules and Recent Trends, 2022.
5. Khule MR, Vyavahare SB. A Review: In-situ Gel Drug Delivery System, 2021.
6. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. 56th ed. Pune: Nirali Prakashan, 2022.
7. Trease GE, Evans WC. Trease and Evans Pharmacognosy. 16th ed. London: Saunders Elsevier, 2009.

8. Harborne JB. Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis. 3rd ed. London: Chapman and Hall, 1998.
9. Indian Pharmacopoeia Commission. Indian Pharmacopoeia. Ghaziabad: IPC, 2022.
10. World Health Organization. WHO Guidelines on Good Agricultural and Collection Practices (GACP) for Medicinal Plants. Geneva: WHO, 2003.
11. Aulton ME, Taylor KMG. Aulton's Pharmaceutics: The Design and Manufacture of Medicines. 6th ed. London: Elsevier, 2022.
12. Ansel HC, Allen LV, Popovich NG. Pharmaceutical Dosage Forms and Drug Delivery Systems. 10th ed. Philadelphia: Lippincott Williams & Wilkins, 2014.
13. Lieberman HA, Rieger MM, Banker GS. Pharmaceutical Dosage Forms: Disperse Systems. New York: Marcel Dekker, 1998.
14. Shah VP, Elkins JS, Williams RL. Evaluation of topical drug products. Pharmaceutical Research,1999:16(3):353–357.
15. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids: An overview. Scientific World Journal,2013:2013:162750.
16. Cowan MM. Plant products as antimicrobial agents. Clinical Microbiology Reviews,1999:12(4):564–582.
17. Gupta VK, Fatima A, Faridi U, *et al*. Antimicrobial potential of *Clerodendrum serratum*. Journal of Ethnopharmacology,2008:116(2):239–242.
18. Kirtikar KR, Basu BD. Indian Medicinal Plants. Vol. III. Dehradun: International Book Distributors, 2005.
19. Nadkarni KM. Indian Materia Medica. Mumbai: Popular Prakashan, 2007.
20. Rastogi RP, Mehrotra BN. Compendium of Indian Medicinal Plants. New Delhi: CSIR, 2002.
21. Ghule BV, Murugananthan G, Nakhat PD, Yeole PG. Analgesic and anti-inflammatory activities of *Clerodendrum serratum* root extract. Pharmacologyonline,2007:2:120–130.
22. Singh M, Khare G, Iyer SK, Sharma G, Tripathi DK. *Clerodendrum serratum*: A clinical approach. Journal of Applied Pharmaceutical Science,2012:2(2):11–15.
23. Praveen Kumar A, Nishteswar K. Phytochemical and pharmacological profile of *Clerodendrum serratum* Linn.: A review. International Journal of Research in Ayurveda and Pharmacy,2013:4(2):276–278.
24. Bhangare NK, Pansare TA, Ghoongane BB, Nesari TM. Screening of anti-inflammatory and anti-allergic activity of Bharangi (*Clerodendrum serratum* Linn.) in animals. International Journal of Pharma and Bio Sciences,2014:5(4):245–254.
25. Dixit G, Misal G, Gulkari V, Upadhye K. Formulation and evaluation of polyherbal gel for anti-inflammatory activity. International Journal of Pharmaceutical Sciences and Research,2013:4(3):1186–1191.
26. Mishra US, Murthy PN, Sahu K. Formulation and standardization of herbal gel containing methanolic extract of *Calophyllum inophyllum*. Asian Journal of Pharmaceutical Technology and Research,2011:1(1):276–289.
27. Niyogi P, Raju NJ, Reddy PG, Rao BG. Formulation and evaluation of anti-inflammatory activity of *Solanum pubescens* extract gel. International Journal of Pharmaceutical Sciences,2012:2(3):484–490.
28. Chatterjee P, Chandra S, Dey P, Bhattacharya S. Evaluation of anti-inflammatory effects of green tea and black tea: A comparative *in vitro* study. Journal of Advanced Pharmaceutical Technology & Research,2012:3(2):136–138.
29. Sastri TK, Gupta VN, Chakraborty S, *et al*. Novel gels: An emerging approach for delivering therapeutic molecules and recent trends. Gels,2022:8(6):316.