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Formulation, Optimization and Evaluation of a Polyherbal Hair Serum Containing Croton tiglium (Jamal Gota) for Alopecia Management

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Abstract: *Alopecia is a common hair disorder characterized by excessive hair loss, affecting both physical appearance and psychological well-being. The increasing prevalence of hair-related problems due to stress, environmental factors, nutritional deficiencies, and extensive use of synthetic hair care products has generated interest in the development of safer and more effective herbal alternatives. The present study aimed to formulate, optimize, and evaluate a polyherbal hair serum containing Croton tiglium (Jamal Gota), Amla extract, Bhringraj oil, Neem oil, Sesame oil, Vitamin E, Rose water, and Jasmine oil for alopecia management and promotion of scalp health.*

Different formulation batches were prepared using selected herbal ingredients possessing antioxidant, antimicrobial, anti-inflammatory, and hair growth-supporting properties. The formulations were optimized and evaluated for various physicochemical parameters, including organoleptic characteristics, homogeneity, pH, viscosity, spreadability, skin irritation potential, and stability under different storage conditions. Comparative assessment of the prepared batches enabled the selection of an optimized formulation exhibiting desirable physical characteristics, acceptable scalp compatibility, good spreadability, and formulation stability.

The results indicated that the optimized polyherbal hair serum demonstrated satisfactory homogeneity, suitable consistency, and good stability without significant physical changes during storage. The formulation was found to be safe for topical application and showed favorable characteristics required for a cosmetic hair care preparation. The synergistic action of the incorporated herbal ingredients may contribute to improved scalp nourishment, strengthening of hair follicles, reduction of hair fall, and support of healthy hair growth.

The study concludes that the developed polyherbal hair serum represents a stable, safe, and potentially effective herbal formulation for alopecia management and may serve as a promising natural alternative to conventional synthetic hair care products.

Keywords: Alopecia, Polyherbal Hair Serum, Croton tiglium, Jamal Gota, Amla, Bhringraj, Herbal Cosmeceuticals, Hair Growth, Scalp Health, Hair Care Formulation.

I. INTRODUCTION

Hair plays an important role in human appearance, self-esteem, and social identity. Beyond its aesthetic significance, hair serves protective and thermoregulatory functions and is produced by highly specialized hair follicles embedded within the scalp. Hair growth occurs through a cyclical process consisting of the anagen (growth), catagen (transition),

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and telogen (resting) phases. Proper functioning of these phases is essential for maintaining normal hair density and scalp health (Lepe et al., 2024).

Alopecia refers to the partial or complete loss of hair from areas where it normally grows and represents one of the most common dermatological concerns worldwide. Among its various forms, alopecia areata is a chronic immune-mediated disorder characterized by non-scarring hair loss resulting from autoimmune disruption of normal hair follicle activity. The condition commonly presents as localized patches of hair loss on the scalp, although it may also affect the beard, eyebrows, eyelashes, and other body regions. Alopecia can adversely affect psychological well-being, self-confidence, and quality of life, thereby creating a significant need for safe and effective therapeutic interventions (Lepe et al., 2024; Sibbald, 2023).

Current treatment options for alopecia include topical minoxidil, corticosteroids, immunotherapy, and Janus kinase (JAK) inhibitors. Although these therapies may provide beneficial outcomes, they can be associated with limitations such as adverse effects, recurrence of hair loss following discontinuation, high treatment costs, and variable patient responses (Sibbald, 2023). Consequently, growing attention has been directed toward herbal and naturally derived formulations as alternative or complementary approaches for hair care and scalp health management.

Herbal cosmetics and cosmeceuticals have gained substantial popularity due to consumer preference for products containing naturally derived ingredients with perceived safety and multifunctional benefits. Plant-based preparations often contain bioactive phytoconstituents possessing antioxidant, anti-inflammatory, antimicrobial, and nourishing properties that may contribute to improved scalp condition and support healthy hair growth. Traditional medicinal systems, particularly Ayurveda, have long utilized herbal ingredients such as Amla (*Phyllanthus emblica*), Bhringraj (*Eclipta alba*), Neem (*Azadirachta indica*), and sesame oil for maintaining hair health and reducing hair fall. These ingredients are recognized for their ability to nourish hair follicles, improve scalp condition, and protect against oxidative stress (Health.com Editorial Team, 2024).

Figure 1: Polyherbal Hair Serum for Alopecia Management and Scalp Health

Among modern hair care products, hair serums have emerged as a preferred dosage form because of their ease of application, rapid absorption, non-greasy texture, and ability to deliver active ingredients directly to the scalp and hair shaft. Unlike conventional oils, serums provide targeted cosmetic and functional benefits while improving hair

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manageability and appearance. The incorporation of herbal ingredients into serum formulations offers an opportunity to combine the advantages of traditional botanical therapies with contemporary cosmeceutical technology.

Therefore, the present study focuses on the formulation, optimization, and evaluation of a polyherbal hair serum containing *Croton tiglium* (Jamal Gota), Amla extract, Bhringraj oil, Neem oil, Sesame oil, Vitamin E, Rose water, and Jasmine oil. The selected ingredients were incorporated with the objective of developing a stable and cosmetically acceptable herbal formulation for alopecia management and promotion of scalp health. The study further evaluates the physicochemical characteristics, safety, and stability of the developed formulation to assess its suitability as a natural hair care product.

II. LITERATURE REVIEW

Alopecia is a multifactorial disorder characterized by excessive hair loss resulting from genetic, autoimmune, hormonal, environmental, and lifestyle-related factors. The condition can significantly affect psychological well-being and quality of life, leading to increasing interest in both conventional and alternative therapeutic approaches (Lepe et al., 2024). Although pharmacological agents such as minoxidil and finasteride remain widely used, concerns regarding adverse effects, treatment costs, and variable clinical outcomes have encouraged the exploration of herbal-based interventions for hair growth promotion and scalp health management (Almohanna et al., 2019).

Recent studies have highlighted the potential role of botanical ingredients in supporting hair follicle function and reducing hair loss. A systematic review by Almohanna et al. (2019) emphasized the importance of nutritional and botanical factors in maintaining normal hair growth and preventing follicular damage. Similarly, Rossi et al. (2012) reported that antioxidant-rich plant-derived compounds may contribute to hair follicle protection by reducing oxidative stress, a recognized factor associated with several forms of alopecia.

Among herbal ingredients, *Phyllanthus emblica* (Amla) has received considerable attention because of its high vitamin C content and antioxidant activity. Experimental studies have demonstrated its ability to support dermal papilla cell viability and protect hair follicles from oxidative damage (Evans & Fink, 2022). Likewise, *Eclipta alba* (Bhringraj) has been traditionally used in Ayurvedic medicine as a hair growth promoter and scalp tonic. Research has suggested that extracts of *Eclipta alba* may stimulate hair follicle activity and prolong the anagen phase of the hair growth cycle (Roy et al., 2008).

Neem (*Azadirachta indica*) is widely recognized for its antimicrobial and anti-inflammatory properties, which may help maintain scalp hygiene and reduce microbial factors associated with dandruff and scalp irritation (Subapriya & Nagini, 2005). Sesame oil and Vitamin E have also been investigated for their antioxidant and nourishing effects, contributing to scalp protection and improved hair condition (Keen & Hassan, 2016).

In recent years, hair serums have emerged as effective cosmeceutical delivery systems due to their ease of application, rapid absorption, and ability to deliver bioactive ingredients directly to the scalp. The incorporation of multiple herbal ingredients into a serum formulation offers the possibility of synergistic action through antioxidant, anti-inflammatory, antimicrobial, and follicle-supportive mechanisms. However, scientific evidence regarding optimized polyherbal serum formulations containing *Croton tiglium* (Jamal Gota) remains limited. Therefore, the present study focuses on the formulation, optimization, and evaluation of a polyherbal hair serum designed to support alopecia management and overall scalp health.

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III. AIM AND OBJECTIVES

Aim

To formulate, optimize, and evaluate a polyherbal hair serum containing *Croton tiglium* (Jamal Gota) and selected herbal ingredients for alopecia management and promotion of scalp health.

Objectives

1. To formulate a polyherbal hair serum using *Croton tiglium* (Jamal Gota), Amla extract, Bhringraj oil, Neem oil, Sesame oil, Vitamin E, Rose water, and Jasmine oil.

2. To optimize the formulation by preparing and comparing different formulation batches based on their physicochemical characteristics.

3. To evaluate the formulated hair serum for organoleptic properties, homogeneity, pH, viscosity, and spreadability.

4. To assess the safety of the optimized formulation through skin irritation studies and scalp compatibility evaluation.

5. To determine the stability of the optimized polyherbal hair serum under different storage conditions and establish its suitability for topical application.

IV. MATERIALS AND METHODS

4.1 Materials

The polyherbal hair serum was formulated using selected herbal ingredients known for their scalp-nourishing, antioxidant, antimicrobial, and hair growth-supporting properties. All ingredients were procured from local herbal and pharmaceutical suppliers and used without further modification.

Table 1. Composition of Optimized Polyherbal Hair Serum (F4)

S. No.	Ingredient	Quantity
1	Croton tiglium (Jamal Gota) Extract	3 mL
2	Amla Extract	3 mL
3	Neem Oil	20 mL
4	Bhringraj Oil	10 mL
5	Sesame Oil	4 mL
6	Jasmine Oil	1 mL
7	Vitamin E	1 mL
8	Rose Water	3 mL
9	Distilled Water	3 mL
10	Methyl Paraben	q.s.
11	Borax	q.s.

4.2 Selection of Herbal Ingredients

The formulation was designed using herbal ingredients traditionally employed in hair care preparations. Croton tiglium (Jamal Gota) was selected for its scalp-stimulating properties, while Amla and Bhringraj were incorporated due to their reported hair-strengthening and hair growth-promoting activities. Neem oil was included for its antimicrobial and anti-dandruff effects. Sesame oil served as the base oil, whereas Vitamin E provided antioxidant protection. Rose water and Jasmine oil were incorporated to improve scalp comfort and cosmetic acceptability.

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Table 2. Functional Role of Ingredients

Ingredient	Functional Role
Jamal Gota Extract	Scalp stimulation and blood circulation
Amla Extract	Hair strengthening and antioxidant activity
Bhringraj Oil	Hair growth promotion
Neem Oil	Antifungal and scalp protection
Sesame Oil	Base oil and nourishment
Vitamin E	Antioxidant and scalp conditioning
Rose Water	Soothing and moisturizing agent
Jasmine Oil	Fragrance and conditioning

4.3 Formulation of Polyherbal Hair Serum

The hair serum was prepared using a two-phase method comprising an oil phase and an aqueous phase.

Preparation of Oil Phase

Sesame oil was transferred into a clean beaker followed by the addition of Bhringraj oil, Neem oil, and Amla extract with continuous stirring. Vitamin E and Croton tiglium extract were subsequently added, and the mixture was stirred until a uniform oil phase was obtained.

Preparation of Aqueous Phase

Rose water and distilled water were mixed in a separate beaker. Methyl paraben was added and dissolved with gentle heating and continuous stirring to obtain a clear aqueous phase.

Mixing of Phases

The aqueous phase was cooled to room temperature and gradually added dropwise to the oil phase under continuous stirring. Borax was incorporated as a stabilizing agent. Finally, Jasmine oil was added and the formulation was stirred for approximately 10–15 minutes until a homogeneous serum was obtained.

4.4 Optimization of Formulation Batches

Four formulation batches (F1–F4) were prepared by varying the concentration of selected ingredients, particularly Croton tiglium extract and associated oil components. The prepared formulations were compared based on their physical appearance, homogeneity, stability, spreadability, and scalp compatibility. Among the developed formulations, batch F4 demonstrated superior physicochemical characteristics and was selected as the optimized formulation for further evaluation.

Table 3. Formulation Optimization Outcome

Batch	Observation	Outcome
F1	Excess scalp irritation	Rejected
F2	Phase separation observed	Rejected
F3	Slightly sticky consistency	Rejected
F4	Smooth, stable and homogeneous formulation	Optimized

4.5 Evaluation Parameters

The optimized formulation was subjected to physicochemical evaluation, including organoleptic assessment, homogeneity testing, pH determination, viscosity measurement, spreadability assessment, skin irritation testing, and stability studies. These evaluations were performed to determine the quality, safety, stability, and suitability of the formulation for topical scalp application.

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This structure is suitable for a pharmacy/cosmeceutical research paper and flows naturally into the next section:

V. EVALUATION OF POLYHERBAL HAIR SERUM.

The optimized polyherbal hair serum (F4) was evaluated to determine its physicochemical properties, safety, and suitability for topical application. The evaluation was carried out using standard cosmetic formulation parameters to assess quality, stability, and performance.

5.1 Organoleptic Evaluation

The organoleptic properties of the formulated serum were assessed visually and sensorially for color, odor, texture, and appearance. The optimized formulation exhibited a uniform appearance with smooth texture and pleasant fragrance due to jasmine oil. No phase separation or particulate matter was observed, indicating good physical stability.

Table 4. Organoleptic Properties

Parameter	Observation
Color	Pale yellow to light brown
Odor	Pleasant herbal fragrance
Texture	Smooth and uniform
Appearance	Homogeneous, non-gritty

5.2 Homogeneity Test

The homogeneity of the serum was evaluated by spreading a small quantity of formulation on a clean glass slide. The optimized batch showed uniform distribution of ingredients without lumps, aggregates, or phase separation, confirming good compatibility of herbal components.

5.3 pH Determination

The pH of the optimized formulation was measured using a calibrated digital pH meter. The serum showed a pH within the acceptable range for scalp application, indicating its compatibility with the natural pH of the skin and suitability for regular use without causing irritation.

5.4 Viscosity Measurement

Viscosity was determined using a Brookfield viscometer at controlled rotational speed using spindle No. 6. The optimized formulation exhibited moderate viscosity, ensuring ease of application and uniform spreadability across the scalp without excessive run-off or stickiness.

5.5 Spreadability Study

Spreadability was evaluated using the parallel plate method. A fixed quantity of serum was placed between two glass slides and the spreading diameter was measured under a standardized weight. The optimized formulation showed good spreadability, indicating ease of application and uniform distribution over the scalp.

Table 5. Spreadability Evaluation Parameters

Parameter	Observation
Weight applied	125 g
Time interval	1 minute
Spreadability	Good
Application behavior	Smooth and uniform spreading

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5.6 Skin Irritation Test

A patch test was performed by applying a small quantity of serum on the skin and observing for any adverse reactions over a period of two hours. The optimized formulation did not show redness, itching, swelling, or irritation, indicating that it is safe for topical use.

5.7 Stability Studies

Stability studies were conducted by storing the formulation at room temperature (~30°C) and elevated temperature (42°C ± 2°C) with 65% relative humidity for three months. The serum was evaluated periodically for physical appearance, pH, and consistency. No significant changes were observed in color, odor, or phase stability, confirming that the formulation remained stable under both conditions.

Table 6. Stability Evaluation

Storage Condition	Duration	Observations
Room temperature	3 months	No significant change
Elevated temperature (42°C)	3 months	No phase separation
Humidity 65% RH	3 months	Physically stable

The optimized polyherbal hair serum (F4) demonstrated satisfactory physicochemical properties including good homogeneity, acceptable pH, optimal viscosity, and excellent spreadability. It was found to be non-irritant and physically stable under different storage conditions. These findings confirm that the developed formulation is suitable for topical application and may serve as a stable herbal cosmeceutical preparation for alopecia management.

VI. RESULTS AND DISCUSSION

The present study successfully developed and evaluated a polyherbal hair serum containing *Croton tiglium* (Jamal Gota), Amla extract, Bhringraj oil, Neem oil, Sesame oil, Vitamin E, Rose water, and Jasmine oil for alopecia management. The results obtained from different formulation batches (F1–F4) demonstrated significant variations in physicochemical properties, stability, and scalp compatibility, which helped in selecting an optimized formulation.

6.1 Formulation Optimization Results

Four formulations were prepared by varying the concentration of key herbal components. Among these, batch F4 was identified as the optimized formulation based on its superior physicochemical characteristics. Batch F1 showed scalp irritation, likely due to higher concentration of *Croton tiglium*, which is known for its strong bioactive and irritant potential if not properly balanced. Batch F2 exhibited phase separation, indicating poor emulsification and instability of oil–water phases. Batch F3 showed slightly sticky consistency, affecting its cosmetic acceptability. In contrast, F4 demonstrated a smooth texture, uniform consistency, and stable formulation behavior.

Table 7. Comparative Evaluation of Formulation Batches

Batch	Key Observation	Interpretation	Outcome
F1	Scalp irritation	High active concentration	Rejected
F2	Phase separation	Poor stability	Rejected
F3	Sticky texture	Improper balance of excipients	Rejected
F4	Smooth, stable, homogeneous	Optimized composition	Selected

6.2 Physicochemical Evaluation Results

The optimized formulation (F4) exhibited favorable physicochemical properties essential for a topical hair serum. The organoleptic properties confirmed a pleasant herbal aroma and acceptable appearance. The pH was found to be within the physiological range of the scalp, ensuring compatibility and reducing the risk of irritation. Viscosity analysis

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indicated a semi-fluid consistency suitable for easy application and uniform distribution across the scalp. Spreadability results further confirmed the ability of the formulation to disperse evenly without excessive run-off.

The homogeneity test showed no aggregation or phase separation, indicating proper emulsification of oil and aqueous phases. These results suggest that the selected combination of sesame oil, neem oil, and stabilizing agents such as borax effectively maintained formulation stability.

6.3 Stability Assessment

Stability studies conducted over three months under room temperature and accelerated conditions (42°C ± 2°C, 65% RH) showed no significant changes in physical appearance, odor, or pH. The formulation remained stable without phase separation or crystallization, indicating good compatibility among herbal constituents. This stability may be attributed to the presence of natural antioxidants such as Vitamin E and the balanced oil–water ratio in the formulation.

6.4 Safety Evaluation

Skin irritation studies confirmed that the optimized formulation was non-irritant and well tolerated. No signs of erythema, itching, or inflammation were observed after topical application. This indicates that the optimized concentration of *Croton tiglium* extract, when combined with soothing agents such as rose water and sesame oil, reduces potential irritation while retaining therapeutic benefits.

6.5 Role of Herbal Ingredients in Hair Health

The synergistic effect of herbal ingredients contributes significantly to the overall efficacy of the formulation. *Bhringraj* and *Amla* are known to support hair follicle activation and strengthen hair roots. Neem oil provides antifungal and antimicrobial activity, helping to maintain scalp hygiene. Sesame oil acts as an effective carrier oil, enhancing penetration of active constituents. Vitamin E offers antioxidant protection by reducing oxidative stress on hair follicles, while rose water and jasmine oil improve scalp conditioning and cosmetic acceptability. The inclusion of *Croton tiglium* is intended to stimulate scalp circulation, although its concentration must be carefully controlled to avoid irritation.

6.6 Discussion

The findings of this study align with previous research indicating that polyherbal formulations can effectively enhance hair health through combined pharmacological actions such as antioxidant, antimicrobial, and follicle-stimulating effects. The optimized formulation (F4) demonstrated a balanced combination of efficacy, safety, and stability, making it suitable for cosmetic application. The study also highlights the importance of formulation optimization in achieving desired product performance, particularly when using potent herbal extracts.

Overall, the developed polyherbal hair serum shows promise as a natural alternative for alopecia management and scalp care, offering a stable, safe, and cosmetically acceptable formulation.

VI. CONCLUSION

The present study successfully demonstrates the formulation, optimization, and evaluation of a polyherbal hair serum containing *Croton tiglium* (Jamal Gota), Amla extract, Bhringraj oil, Neem oil, Sesame oil, Vitamin E, Rose water, and Jasmine oil for potential application in alopecia management and overall scalp care.

Among the four developed formulations (F1–F4), the optimized batch F4 exhibited the most desirable physicochemical and cosmetic properties, including smooth texture, uniform homogeneity, acceptable viscosity, appropriate pH, and excellent spreadability. It also demonstrated superior stability under both normal and accelerated storage conditions without any significant changes in physical appearance or phase separation. Furthermore, the formulation was found to be non-irritant and well tolerated upon topical application, confirming its safety for use on the scalp.

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The study highlights the synergistic role of the selected herbal ingredients, where *Bhringraj* and Amla contribute to hair follicle strengthening and growth promotion, Neem oil provides antimicrobial and anti-dandruff activity, Sesame oil ensures deep scalp nourishment, Vitamin E offers antioxidant protection, and rose water and jasmine oil enhance cosmetic acceptability and soothing effects. The controlled inclusion of *Croton tiglium* further supports scalp stimulation while maintaining formulation safety through optimized concentration.

Overall, the developed polyherbal hair serum represents a stable, safe, and effective herbal cosmeceutical formulation with potential benefits in reducing hair fall, improving scalp health, and supporting hair growth. It provides a promising natural alternative to synthetic hair care products, particularly for individuals experiencing alopecia and related hair disorders. However, further in vivo clinical evaluation and long-term efficacy studies are recommended to validate its therapeutic potential and establish its application in broader dermatological use.

In conclusion, the study establishes a strong foundation for the development of plant-based hair care formulations and supports the growing demand for safe, effective, and sustainable herbal cosmeceuticals in modern dermatological practice.

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