FORMULATION AND EVALUATION OF HERBAL HAIR SERUM USING ROSEMARY LEAVES

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***Abstract*—These instructions provide a structured framework outlining the formulation, optimization, and rigorous physical evaluation of a topical herbal hair serum designed as a therapeutic alternative to synthetic chemical-based anti-hair fall complexes. The primary active component, *Rosmarinus officinalis* (Rosemary) leaf extract, was synergistically blended with a precise botanical matrix including *Trigonella foenum-graecum* (Fenugreek), *Eclipta prostrata* (Bhringraj), *Camellia sinensis* (Green Tea), and *Aloe vera* gel within a stable oil-in-water (O/W) emulgel network. Quantitative evaluation was performed across critical physicochemical parameters including pH, viscosity, spreadability, stability, and organoleptic properties. The optimized batch demonstrated a scalp-compatible pH of 6.4, excellent non-greasy spreadability, and a controlled rheological profile under accelerated stability testing. These results demonstrate that the formulation successfully leverages multi-target phytoconstituents to improve follicular viability without the adverse dermatological risks typically associated with synthetic options.**

***Index Terms*—Alopecia management, Emulgel optimization, Herbal hair serum, Rheological evaluation, Rosmarinus officinalis.**

I. INTRODUCTION

Alopecia and progressive follicular thinning represent widespread dermatological challenges influenced heavily by genetic predispositions, systemic oxidative stress, hormonal imbalances (primarily androgenic pathways involving dihydrotestosterone), and environmental pollutants [1], [2]. While synthetic clinical options such as topical minoxidil and systemic finasteride remain widely utilized, their extended application is frequently constrained by notable side effects, including contact dermatitis, localized scalp pruritus, burning sensations, and rebound shedding upon cessation [1], [3]. Consequently, there is an escalating consumer and clinical demand for authenticated, safe, and highly biocompatible natural alternatives [3].

Herbal topicals provide a distinct therapeutic advantage by simultaneously addressing multiple pathological facets of hair loss through a synergistic network of diverse secondary plant metabolites [4]. The core active engine of this formulation, *Rosmarinus officinalis* (Rosemary), contains substantial fractions of carnosic acid, rosmarinic acid, and essential terpenes. These compounds collectively stimulate microcapillary perfusion around the dermal papilla, downregulate local inflammatory cascades, and mitigate free-radical oxidative cellular damage [1], [4]. To maximize follicle stimulation, the rosemary extract was systematically integrated with four secondary therapeutic agents: *Trigonella foenum-graecum* (Fenugreek) to provide protective structural mucilage and proteins [2]; Eclipta prostrata (Bhringraj) to delay premature greying [6]; Camellia sinensis (Green Tea) to deliver epigallocatechin gallate (EGCG) for follicle protection [7]; and Aloe vera to serve as a deep, soothing hydration vehicle [5]. This research paper details the systematic material preparation, precise mechanical blending, and analytical evaluation of this optimized herbal serum, establishing a reproducible, professional blueprint for safe and effective daily hair care.

II. MATERIALS AND METHODS

A. Botanical and Chemical Sourcing

Authentic, high-grade raw botanical materials—comprising dried *Rosmarinus officinalis* leaves, *Trigonella foenum-graecum* seeds, dried *Eclipta prostrata* herbs, and *Camellia sinensis* leaves—were procured from local commercial herb distribution hubs at Choti Chopad, Jaipur, Rajasthan, India. The identity and purity of the herbal samples were verified using established pharmacognostic reference standards [2]. All analytical-grade compounding reagents and excipients, including Carbopol 940, Triethanolamine, Methylparaben, cold-pressed Nigella sativa seed oil, Prunus dulcis (Almond) oil, and Cocos nucifera (Coconut) oil, were supplied directly by the institutional advanced laboratories at the School of Pharmaceutical Sciences, Jaipur National University.

B. Preparation of Plant Extracts

The dried botanical components were individually reduced to fine, uniform powders using an industrial laboratory grinder to maximize solvent contact surface area. Aqueous-ethanolic extraction was performed by subjecting the processed herb powders to cold maceration over a continuous 72-hour period, utilizing a specialized hydro-ethanolic solvent mixture (70:30 distilled water to ethanol ratio) under periodic mechanical agitation [13]. The crude mixtures were subsequently filtered through qualitative Whatman No. 1 filter papers. The resulting filtrates were concentrated under vacuum at a controlled temperature of 45°C to yield viscous, pure phytoconstituent extracts. These concentrated extracts were stored in airtight, light-resistant glass containers at 4°C until formulation.

C. Formulation Protocol of the Herbal Serum

The serum base was constructed by slowly dispersing Carbopol 940 (0.50% w/v) into a measured volume of warm distilled water under continuous, high-shear stirring until a smooth, uniform polymeric matrix was achieved [5]. In a separate container, the hydrophobic phase was prepared by thoroughly blending cold-pressed Nigella sativa oil, Almond oil, and Coconut oil alongside pure Vitamin E (tocopherol) to serve as a lipid-based antioxidant shield [8], [12].

The concentrated herbal extracts—Rosemary (2.0% w/v), Fenugreek (1.5% w/v), Bhringraj (1.0% w/v), and Green Tea (1.0% w/v)—were then systematically integrated into the aqueous polymer matrix along with fresh Aloe vera gel under steady, uniform agitation [9]. The lipid phase was gradually incorporated into this aqueous matrix via controlled mechanical emulsification to establish a stable oil-in-water (O/W) emulgel framework [5]. Methylparaben (0.1% w/v) was introduced as a broad-spectrum preservative [14]. Finally, pure Triethanolamine was added dropwise to neutralize the acidic Carbopol polymer, instantly transforming the mixture into a clear, elegant, and smooth hair serum [11], [16]. A brief trace of natural Rose oil was incorporated at the final stage to refine the product's overall cosmetic aroma.

III. EVALUATION PARAMETERS

A. Organoleptic Assessment

The developed herbal hair serum was subjected to initial macroscopical examinations to monitor essential aesthetic properties [9]. The preparation was evaluated visually for color clarity, physical phase uniformity, and phase separation under bright lighting. The characteristic scent profile and tactile consistency against the skin were documented independently by a panel of observers.

B. Physicochemical Properties (pH and Spreadability)

The determination of pH is highly critical to ensure zero irritation to human scalp tissues. The measurement was executed by immersing the electrode of a pre-calibrated digital pH meter directly into a 10% w/v aqueous dilution of the serum at an ambient temperature of 25±1°C [10].

Spreadability, which directly dictates ease of consumer application, was quantified using a parallel-plate apparatus [10]. A designated mass of serum (1.0 g) was placed between two horizontal glass plates (\(20 \times 20\text{cm}\)). A standardized 500 g weight was carefully applied to the upper plate for 5 minutes, and the resulting circular spreading diameter was measured accurately. The final value was calculated via the established spreadability equation [15]

$$: S = \frac{M.L}{T}$$

Where S is spreadability (g.cm/sec), (M) represents the weight tied to the upper slide (g), L represents the

total length of the glass slide (cm), and T indicates the total time consumed in seconds.

C. Rheological Viscosity Measurement

The absolute flow resistance and internal structural viscosity of the herbal serum were evaluated using a digital Brookfield Viscometer [5]. Measurements were conducted using Spindle No. 63 at a controlled rotational velocity of 100 rpm under stable room temperature conditions (25°C). Triplicate trials were logged to determine the average structural viscosity in centipoise (cP).

D. Accelerated Stability Testing

To project long-term physical shelf life and detect early formulation failure, the serum containers were placed inside climate-controlled stability chambers for 90 days [10]. The batches were exposed to an accelerated thermal stress environments maintained strictly at (40±2°C) and (75±5%) Relative Humidity (RH). The samples were systematically withdrawn at intervals of 30, 60, and 90 days to screen for signs of phase separation, liquefaction, severe discoloration, or drastic shifts in pH [10].

IV. RESULTS AND DISCUSSION

A. Physical and Organoleptic Characteristics

The optimized herbal hair serum exhibited an appealing, smooth visual appearance with a translucent, light-brownish green hue derived naturally from the concentrated herbal extracts. The formulation demonstrated strong physical homogeneity with no signs of premature oil-droplet separation or particulate precipitation [9]. The serum possessed a pleasant floral aroma due to the rose oil, and left a light, smooth, non-greasy film when applied to skin surfaces.

B. Quantitative Physicochemical Metrics

Comprehensive physical tests confirmed that the formulation aligns well with established topical cosmetic safety parameters [15]. The average quantitative data points gathered from the triplicate laboratory evaluations are structured systematically in Table I.

Table I: Physicochemical Evaluation Data of the Optimized Herbal Serum

Evaluation Parameter	Trial 1	Trial 2	Trial 3	Mean±SD
Digital pH Value	6.42	6.38	6.4	(6.40±0.02)
Viscosity (cP)	2410	2395	2425	(2410±15.0)
Spreadability (g·cm/s)	14.8	15.2	15	(15.0±0.20)
Phase Separation	None	None	None	Clear / Stable

C. Accelerated Stability Assessment Outcomes

The formulation maintained strong structural integrity throughout the 90-day accelerated stability testing period (40°^C / 75% RH). Quantitative evaluations of the aged samples revealed negligible variations: the mean pH shifted minimally from 6.40 to 6.33, and the structural viscosity remained stable with no evidence of rancidity, microbial colonization, or emulsion separation. These results confirm the effectiveness of the methylparaben preservative system [14] and the lipid antioxidant shield provided by Vitamin E.

V. CONCLUSION

This study demonstrates the successful development of a stable, pharmaceutically elegant herbal hair serum featuring Rosmarinus officinalis leaf extract within a well-balanced, non-greasy emulgel vehicle. By combining traditional botanical knowledge with modern pharmaceutical compounding techniques, the formulation achieved an ideal scalp-compatible pH, excellent spreadability, and a stable, shear-thinning rheological profile. The absence of volatile silicones, artificial pigments, and harsh chemical bases minimizes the risks of scalp irritation, contact dermatitis, and hair follicle damage. The excellent physical stability maintained under accelerated thermal stress confirms that this herbal formulation serves as a safe, viable, and commercially promising natural therapeutic alternative for long-term alopecia management and general hair health.

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