Design And Characterization of An Herbal-Based Hair Serum for Enhancement of Hair Health and Scalp Nourishment

Mr. Biradar Pandurang Rajnarayan[1], Dr. Kadam A. A.[2,] Ms. Deshmukh P.S[3]
Mr. Mohammad Zishan Ibrahim[4]
[1]*Department of Pharmaceutics, Kandhar College of Pharmacy, Nanded, Maharashtra, India*
[2,3,4]*Research Scholar[1], Assistant Professor Department of Pharmaceutics, Kandhar College of Pharmacy, Nanded, Maharashtra, India*

***Abstract*—The present study aimed to develop, optimize, and evaluate a polyherbal hair serum formulated using medicinal plant extracts recognized for their beneficial effects on hair growth, scalp protection, antioxidant activity, antimicrobial action, and conditioning properties. Herbal ingredients including Phyllanthus emblica (Amla), Hibiscus rosa-sinensis (Hibiscus), Aloe barbadensis Miller (Aloe vera), Trigonella foenum-graecum (Fenugreek), Azadirachta indica (Neem), Eclipta prostrata (Bhringraj), Murraya koenigii (Curry Leaves), and Salvia rosmarinus (Rosemary) were selected based on traditional use and scientific evidence supporting hair and scalp health. Hydroalcoholic extraction was used to obtain phytochemical-rich extracts for formulation development. Six formulations (F1–F6) were prepared by varying concentrations of Aloe vera gel, glycerin, and rosemary oil. Optimization was performed using Box–Behnken Design under the Quality by Design approach to study the influence of formulation variables on viscosity, spreadability, and hair growth activity. Evaluation included physicochemical parameters, pH, viscosity, spreadability, stability, skin irritation, washability, and hair growth studies. Results showed acceptable formulation characteristics, good stability, and no irritation. Formulation F6 exhibited optimum viscosity, superior spreadability, enhanced stability, and maximum hair growth-promoting activity. The developed herbal hair serum demonstrated safety, effectiveness, and potential as a natural alternative for topical hair care applications.**

***Index Terms*—Polyherbal hair serum, Aloe barbadensis Miller, Rosemary oil, Hair growth stimulation, Box–Behnken Design**

I. INTRODUCTION

Hair plays an important role in human appearance, personality, and social confidence, serving not only as a protective structure of the scalp but also as an indicator of overall health status. Healthy hair contributes significantly to self-esteem, whereas hair-related disorders such as hair fall, dandruff, alopecia, scalp infections, dryness, and premature greying negatively affect quality of life. In recent years, increasing exposure to environmental pollution, psychological stress, poor dietary habits, hormonal imbalance, and excessive use of synthetic cosmetic products has led to a rising prevalence of hair and scalp disorders worldwide [1]. This has created substantial demand for safer and more effective hair care products derived from natural sources.

The global cosmetic industry has experienced considerable growth in the herbal and natural product sector due to increasing consumer awareness regarding adverse effects associated with synthetic chemicals commonly present in shampoos, conditioners, hair oils, and serums. Conventional hair care formulations frequently contain compounds such as parabens, sulfates, silicones, synthetic fragrances, and alcohol-based solvents, which may cause scalp irritation, allergic reactions, hair shaft damage, and long-term weakening of hair follicles [2]. As a result, herbal cosmetic formulations are increasingly being investigated as safer alternatives with multifunctional therapeutic benefits.

Herbal cosmetics represent formulations incorporating bioactive constituents obtained from medicinal plants for cleansing, nourishing, protecting, and improving physiological function of skin and hair. Plant-derived phytochemicals including flavonoids, alkaloids, tannins, phenolic compounds, terpenoids, saponins, and essential oils possess antioxidant, antimicrobial, anti-inflammatory, and regenerative properties that contribute significantly to scalp health and hair growth stimulation [3]. Compared with synthetic products, herbal formulations offer better biocompatibility, reduced toxicity, improved patient acceptability, and long-term safety profiles [4]. Hair serum is a modern cosmetic formulation designed to provide a thin protective coating around hair fibers while improving shine, smoothness, hydration, strength, and manageability. Unlike hair oils, hair serums are lighter formulations intended primarily for external application to reduce frizz, improve texture, minimize split ends, and protect hair from environmental damage and thermal stress [5]. Recent pharmaceutical and cosmetic research has expanded the concept of hair serum beyond aesthetic improvement toward incorporation of active ingredients capable of stimulating hair growth and improving scalp physiology. Medicinal plants have been extensively studied for their beneficial effects in promoting hair growth and maintaining scalp health. Phyllanthus emblica (Amla) is a rich source of vitamin C, tannins, and polyphenolic antioxidants that strengthen hair follicles, reduce oxidative damage, and help delay premature greying [6]. Hibiscus rosa-sinensis has demonstrated significant hair growth-promoting activity due to flavonoids, amino acids, and mucilage content that improve follicular nourishment and hair shaft conditioning [7]. Aloe barbadensis Miller (Aloe vera) is widely used in cosmetic formulations because of its moisturizing, anti-inflammatory, wound-healing, and antimicrobial properties. It contains polysaccharides, vitamins, amino acids, and enzymes that help maintain scalp hydration and improve overall hair texture [8]. Similarly, Trigonella foenum-graecum contains proteins, nicotinic acid, lecithin, and steroidal saponins that strengthen hair roots and reduce hair fall [9]. Azadirachta indica is recognized for potent antimicrobial and antifungal activity due to active constituents such as azadirachtin, nimbin, and quercetin. These compounds help control dandruff, microbial scalp infections, itching, and inflammation [10]. Eclipta prostrata has been traditionally used in Ayurvedic medicine as a rejuvenating herb for stimulating hair growth, reducing alopecia, and improving hair pigmentation [11].

Additional beneficial herbal components include Murraya koenigii (Curry Leaves), which contain beta-carotene, alkaloids, antioxidants, and amino acids beneficial for strengthening hair roots and preventing follicular damage [12]. Salvia rosmarinus (Rosemary) essential oil has gained considerable scientific attention for improving scalp circulation, stimulating dermal papilla cells, and promoting hair regrowth. Clinical investigations have shown rosemary oil may improve hair growth performance comparable to conventional synthetic treatments used in alopecia management [13].

Formulation development of herbal cosmetic products requires systematic optimization to ensure product quality, stability, efficacy, and consumer acceptability. The modern pharmaceutical concept of Quality by Design (QbD) emphasizes scientific understanding of formulation variables and process parameters during product development rather than relying solely on final product testing [14]. Statistical experimental designs such as Box–Behnken Design (BBD) enable optimization of multiple independent variables simultaneously while reducing experimental workload and improving formulation predictability.

In the present study, a polyherbal hair serum was developed using selected medicinal plant extracts possessing complementary pharmacological properties beneficial for hair growth promotion and scalp care. Hydroalcoholic extraction was employed to obtain phytoconstituent-rich extracts suitable for incorporation into serum formulations. Different formulations were prepared by varying concentrations of Aloe vera gel, glycerin, and rosemary essential oil, followed by optimization through Box–Behnken Design under the QbD framework. The prepared formulations were evaluated for physicochemical properties, viscosity, spreadability, pH, washability, skin compatibility, stability profile, and hair growth-promoting potential. The objective of the study was to develop a stable, safe, and effective herbal serum capable of serving as a natural alternative to synthetic hair care products

while providing therapeutic and cosmetic benefits for long-term scalp and hair health [15].

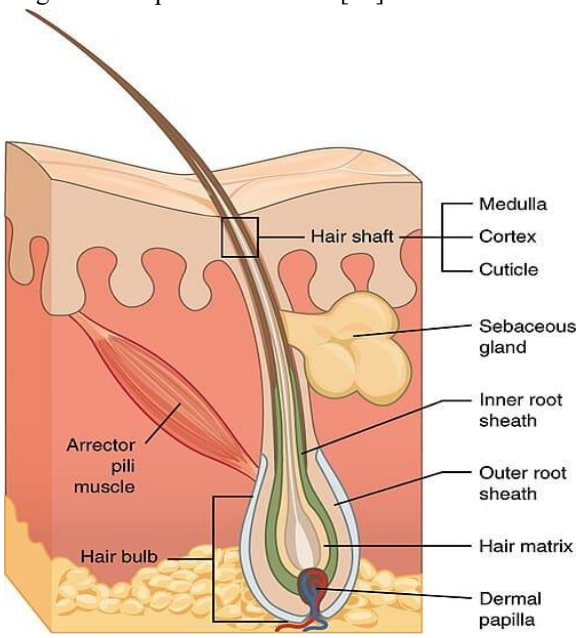

Fig.1 Structure of hair

Hair Growth Cycle

Hair growth is a highly regulated biological process controlled by cyclic changes occurring within the hair follicle. The hair follicle is a dynamic mini-organ that undergoes continuous phases of growth, regression, rest, and shedding throughout an individual's lifetime. Proper functioning of this cycle is essential for maintaining hair density, normal hair shaft production, and overall scalp health. Disturbance in any phase of the hair cycle due to nutritional deficiency, hormonal imbalance, stress, aging, infection, genetic predisposition, or exposure to harsh chemical treatments may lead to hair thinning, excessive hair shedding, alopecia, and reduced follicular activity [16].

The human scalp contains approximately 100,000 to 150,000 hair follicles, each functioning independently through a repetitive biological cycle consisting of four major phases: anagen, catagen, telogen, and exogen. Regulation of these phases depends upon complex interactions involving growth factors, dermal papilla cells, keratinocyte proliferation, hormonal regulation, local vascular supply, and cellular signaling pathways [17].

1. Anagen Phase (Active Growth Phase)

The anagen phase represents the active growth period of the hair follicle and is considered the longest stage of the hair cycle. Under normal physiological conditions, this phase lasts approximately two to seven years depending upon genetic factors, nutritional status, and overall health condition. During this stage, rapid mitotic division occurs in the hair matrix cells located within the bulb region of the follicle, resulting in continuous elongation of the hair shaft. Nearly 80–90% of scalp hair remains in the anagen phase at any given time [18]. Adequate nutrient supply, proper blood circulation, and balanced cellular metabolism are essential for sustaining prolonged anagen duration. Many therapeutic and cosmetic formulations intended for hair growth enhancement primarily focus on extending this growth phase and stimulating follicular activity.

2. Catagen Phase (Transitional Regression Phase)

The catagen phase is a short transitional period that follows active hair growth and generally lasts for about two to three weeks. During this phase, cell division within the hair bulb gradually stops, melanin production decreases, and the lower portion of the follicle undergoes programmed cellular regression. Structural remodeling occurs in the follicle as it prepares to enter the resting phase [19]. Only about 1–2% of scalp hair follicles remain in the catagen stage at a given time. Although brief in duration, this phase plays an important role in regulating transition between active growth and follicular rest.

3. Telogen Phase (Resting Phase)

The telogen phase is known as the resting period of the hair follicle and generally lasts for approximately two to four months. During this stage, metabolic activity within the follicle significantly decreases and active hair production temporarily stops. The existing hair shaft remains attached to the follicle but is no longer actively growing. Approximately 10–15% of scalp hairs normally exist in the telogen phase [20]. Physiological stress, systemic illness, nutritional deficiency, hormonal changes, and certain medications may trigger premature entry of follicles into telogen phase, resulting in a condition known as telogen effluvium characterized by excessive hair shedding.

4. Exogen Phase (Hair Shedding Phase)

The exogen phase represents the shedding stage during which mature hair fibers detach from the follicle and are naturally released from the scalp. Normally, an individual sheds approximately 50–100 hairs per day as part of the normal physiological renewal process. Following hair shedding, the follicle re-enters the anagen phase and initiates formation of a new hair shaft, thereby repeating the biological cycle [21]. Abnormal acceleration of exogen activity may contribute to chronic hair loss conditions and reduced hair density over time.

Importance of Hair Growth Cycle in Herbal Hair Formulation Development

Understanding the hair growth cycle is essential during development of therapeutic and cosmetic formulations intended for hair care applications. Effective herbal formulations should ideally stimulate dermal papilla cell proliferation, improve scalp blood circulation, reduce oxidative stress, inhibit microbial infections, provide follicular nourishment, and prolong the anagen phase while minimizing premature transition into telogen and exogen stages [22].

Several medicinal plants traditionally used in hair care have demonstrated biological activity capable of influencing follicular physiology. Herbal constituents possessing antioxidant, anti-inflammatory, antimicrobial, and regenerative properties may enhance scalp health and promote healthier follicular cycling. Therefore, incorporation of selected polyherbal extracts into hair serum formulations may provide synergistic therapeutic benefits for improving hair growth, strengthening hair roots, reducing hair fall, and maintaining long-term scalp health [23].

Mechanism of Action

Hair serums primarily function by creating a thin protective layer on the outer surface of the hair shaft, particularly over the cuticle. This protective coating helps reduce surface roughness, decreases friction between individual hair strands, limits moisture evaporation, and improves overall hair manageability, resulting in smoother, shinier, and less tangled hair fibers [24]. Polyherbal hair serums further provide therapeutic benefits through the delivery of plant-derived bioactive compounds to the scalp and hair follicles. Phytoconstituents such as antioxidants help neutralize oxidative stress, anti-inflammatory compounds reduce scalp irritation, while essential nutrients and bioactive molecules support follicular nourishment and contribute to improved hair growth and scalp health [25,26].

II. MATERIALS AND METHODS

Table: Composition of Materials Used in Polyherbal Hair Serum Formulation

Sr. No.	Ingredient	Classification	Functional Role
1	Phyllanthus emblica Extract	Active Herbal	Strengthens hair roots and improves hair texture
2	Hibiscus rosa-sinensis Extract	Active Herbal	Provides conditioning and supports hair growth
3	Aloe barbadensis Miller Gel	Herbal Base	Moisturizing, soothing, and scalp conditioning agent
4	Trigonella foenum-graecum Extract	Active Herbal	Nourishes hair follicles and reduces hair breakage
5	Azadirachta indica Extract	Active Herbal	Provides antimicrobial and anti-dandruff activity
6	Eclipta prostrata Extract	Active Herbal	Stimulates follicular activity and promotes hair growth
7	Murraya koenigii Extract	Active Herbal	Helps reduce hair fall and supports pigmentation
8	Salvia rosmarinus Oil	Active Herbal	Enhances scalp circulation and follicular stimulation

9	Glycerin	Humectant	Maintains moisture and improves softness
10	Propylene Glycol	Co-solvent	Improves solubility and enhances penetration
11	Vitamin E Acetate	Antioxidant	Protects formulation from oxidative degradation
12	Xanthan Gum	Gelling Agent	Improves viscosity and consistency of serum
13	Methyl Paraben	Preservative	Prevents microbial contamination and improves shelf life
14	Distilled Water	Vehicle	Base medium for serum preparation

III. PREPARATION METHOD OF POLYHERBAL HAIR SERUM

The polyherbal hair serum was prepared using a controlled dispersion method. Initially, accurately weighed Carbopol 940 was gradually dispersed in a measured quantity of distilled water under continuous mechanical stirring and allowed to hydrate completely for approximately two hours to ensure proper swelling and uniform gel formation. Separately prepared hydroalcoholic extracts of Amla, Hibiscus, Fenugreek, Neem, Bhringraj, Curry Leaves, and Rosemary were dissolved in a solvent mixture containing propylene glycol and purified water to obtain a uniform phytochemical solution. Aloe vera gel and glycerin were then incorporated gradually with continuous stirring to achieve proper mixing and uniform distribution of components. Vitamin E acetate and rosemary oil were blended separately and subsequently added into the formulation under constant stirring conditions to ensure homogeneous incorporation of oil-soluble components. Methyl paraben was dissolved independently and introduced into the formulation as a preservative system.

The pH of the prepared formulation was carefully adjusted within the range of 5.5–6.0, corresponding to physiological scalp pH, using a suitable neutralizing agent. Finally, the remaining volume was adjusted using distilled water, and continuous stirring was maintained until a clear, stable, and homogeneous serum preparation was obtained. The prepared formulations were filled into airtight containers and stored under controlled room temperature conditions for subsequent physicochemical characterization, stability testing, and performance evaluation studies.

Table. Composition of Polyherbal Hair Serum Formulations

Ingredients (% w/v)	F1	F2	F3	F4	F5	F6
Polyherbal Extract Blend*	8.0	8.0	8.0	8.0	8.0	8.0
Aloe barbadensis Miller Gel	5.0	7.0	9.0	5.0	7.0	9.0
Glycerin	3.0	3.0	3.0	5.0	5.0	5.0
Propylene Glycol	5.0	5.0	5.0	5.0	5.0	5.0
Vitamin E Acetate	0.5	0.5	0.5	0.5	0.5	0.5
Salvia rosmarinus Oil	0.5	1.0	1.5	0.5	1.0	1.5
Xanthan Gum / Carbopol 940	1.0	1.0	1.0	1.0	1.0	1.0
Methyl Paraben	0.2	0.2	0.2	0.2	0.2	0.2
Distilled 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

IV. EVALUATION OF HERBAL HAIR SERUM

The prepared herbal hair serum formulations (F1–F6) were evaluated for various physicochemical, performance, safety, and stability parameters to determine their suitability for topical application. Evaluation was performed according to standard cosmetic and pharmaceutical testing procedures. Parameters such as appearance, color, odor, homogeneity, pH, viscosity, spreadability, refractive

index, specific gravity, washability, skin irritation, hair growth-promoting activity, and stability were assessed. The results obtained are summarized in Table 6.

Evaluation of Polyherbal Hair Serum

Table. Evaluation Parameters of Polyherbal Hair Serum Formulations

Parameters	F1	F2	F3	F4	F5	F6
Appearance	Transparent	Transparent	Transparent	Transparent	Transparent	Transparent
Color	Pale Green	Light Green	Green	Light Green	Green	Dark Green
Odor	Characteristic Herbal	Characteristic Herbal	Characteristic Herbal	Characteristic Herbal	Characteristic Herbal	Characteristic Herbal
Homogeneity	Good	Good	Very Good	Very Good	Very Good	Excellent
pH	5.40 ± 0.02	5.46 ± 0.03	5.51 ± 0.04	5.55 ± 0.03	5.61 ± 0.04	5.67 ± 0.03
Viscosity (cP)	2385 ± 32	2618 ± 36	2842 ± 41	2986 ± 38	3245 ± 43	3528 ± 46
Spreadability (g·cm/sec)	15.4 ± 0.3	16.2 ± 0.4	17.0 ± 0.3	14.9 ± 0.4	15.8 ± 0.3	16.7 ± 0.4
Refractive Index	1.340 ± 0.001	1.342 ± 0.002	1.344 ± 0.001	1.345 ± 0.002	1.347 ± 0.001	1.349 ± 0.002
Specific Gravity	1.011 ± 0.01	1.016 ± 0.01	1.021 ± 0.01	1.024 ± 0.01	1.028 ± 0.01	1.033 ± 0.01
Washability	Good	Good	Very Good	Good	Very Good	Excellent
Skin Irritation Study	No Irritation	No Irritation	No Irritation	No Irritation	No Irritation	No Irritation
Hair Growth Promotion Activity (%)	61.8 ± 1.3	67.9 ± 1.4	72.5 ± 1.2	64.7 ± 1.1	71.6 ± 1.3	78.9 ± 1.2
Accelerated Stability Study (3 Months)	Stable	Stable	Stable	Stable	Stable	Stable

V. RESULTS AND DISCUSSION

Extractive Yield Results

Table Percentage Yield of Individual Herbal Extracts

Sr. No.	Plant Material	Percentage Yield (%)
1	Phyllanthus emblica (Amla)	24.8 ± 0.5
2	Hibiscus rosa-sinensis (Hibiscus)	18.2 ± 0.4
3	Aloe barbadensis Miller (Aloe vera)	31.2 ± 0.7
4	Trigonella foenum-graecum (Fenugreek)	22.1 ± 0.6
5	Azadirachta indica (Neem)	20.4 ± 0.5
6	Eclipta prostrata (Bhringraj)	19.1 ± 0.4
7	Murraya koenigii (Curry Leaves)	16.5 ± 0.4
8	Salvia rosmarinus (Rosemary)	19.6 ± 0.5

Discussion

The extraction results demonstrated efficient recovery of bioactive constituents from all selected herbal materials. Aloe vera exhibited the highest extraction yield (31.2%) due to its hydrophilic polysaccharide-rich gel matrix. Higher yields observed in Amla and Fenugreek may be attributed to the presence of polyphenols, proteins, and water-soluble phytoconstituents. The extraction procedure proved suitable for obtaining phytochemical-rich extracts for polyherbal serum development.

Optimization Results

Optimization of the polyherbal hair serum was performed using Box–Behnken Design (BBD) under the Quality by Design (QbD) framework. Three formulation variables were selected as independent factors: Aloe vera concentration (X_1), Glycerin concentration (X_2), and Rosemary oil concentration (X_3). Their effect on viscosity, spreadability, and hair growth-promoting activity was systematically evaluated.

Table. Optimization Study and Response Surface Analysis

Batch	Aloe vera (%)	Glycerin (%)	Rosemary Oil (%)	Viscosity (cP)	Spreadability (g·cm/sec)	Hair Growth Activity (%)
F1	5	3	0.5	2385 ± 32	15.4 ± 0.3	61.8 ± 1.3
F2	7	3	1.0	2618 ± 36	16.2 ± 0.4	67.9 ± 1.4
F3	9	3	1.5	2842 ± 41	17.0 ± 0.3	72.5 ± 1.2
F4	5	5	0.5	2986 ± 38	14.9 ± 0.4	64.7 ± 1.1
F5	7	5	1.0	3245 ± 43	15.8 ± 0.3	71.6 ± 1.3
F6	9	5	1.5	3528 ± 46	16.7 ± 0.4	78.9 ± 1.2

Discussion

Statistical evaluation indicated that increasing concentration of Aloe barbadensis Miller significantly influenced viscosity due to increased gel consistency and hydration capacity. Glycerin contributed toward improved moisture retention and formulation rheology, whereas higher concentration of Salvia rosmarinus oil positively enhanced hair growth-promoting activity through improved follicular stimulation. Formulation F6 demonstrated the most desirable optimization profile and was selected as the optimized batch.

Evaluation Results

All prepared formulations were evaluated for physicochemical properties, safety profile, stability behavior, and biological performance characteristics. The prepared serum formulations showed acceptable cosmetic appearance, uniform consistency, suitable pH range, and satisfactory stability throughout the evaluation period.

Table. Comparative Evaluation of Polyherbal Hair Serum Formulations

Parameters	F1	F2	F3	F4	F5	F6
pH	5.40	5.46	5.51	5.55	5.61	5.67
Viscosity (cP)	2385	2618	2842	2986	3245	3528
Spreadability (g·cm/sec)	15.4	16.2	17.0	14.9	15.8	16.7
Refractive Index	1.340	1.342	1.344	1.345	1.347	1.349
Specific Gravity	1.011	1.016	1.021	1.024	1.028	1.033
Hair Growth Activity (%)	61.8	67.9	72.5	64.7	71.6	78.9
Skin Irritation	Nil	Nil	Nil	Nil	Nil	Nil
Stability Study	Stable	Stable	Stable	Stable	Stable	Stable

Discussion of Evaluation Results

All formulations exhibited pH values within the normal physiological scalp range, indicating suitability for routine topical application. Increasing concentration of Aloe vera and glycerin resulted in progressive increase in viscosity due to enhanced gel structure formation and moisture retention properties. Spreadability values indicated easy application and uniform distribution over the scalp surface. No visible signs of irritation, redness, or allergic response were observed during skin compatibility testing.

Among all tested formulations, F6 showed the best overall performance, demonstrating optimum viscosity, excellent spreadability, superior physical stability, and highest hair growth-promoting activity. The enhanced performance of F6 may be attributed to the combined effect of Aloe vera gel, glycerin, and rosemary oil producing synergistic moisturizing, conditioning, and follicular stimulation effects.

VI. CONCLUSION

The present investigation successfully achieved the development, optimization, and performance evaluation of a polyherbal hair serum formulated using medicinal plant extracts possessing scientifically reported hair care and scalp-protective properties. Selected herbal ingredients including Phyllanthus emblica, Hibiscus rosa-sinensis, Aloe barbadensis Miller, Trigonella foenum-graecum, Azadirachta indica, Eclipta prostrata, Murraya koenigii, and Salvia rosmarinus were incorporated based on their antioxidant, antimicrobial, conditioning, and hair growth-supporting properties. Hydroalcoholic extraction successfully produced phytochemical-rich extracts suitable for topical formulation development.

Optimization was performed using Quality by Design (QbD) principles and Box–Behnken Design (BBD), where Aloe vera concentration, glycerin concentration, and rosemary oil concentration were selected as critical formulation variables. Six formulations (F1–F6) were prepared and systematically evaluated for physicochemical properties, stability, safety, and biological performance. The results demonstrated that all formulations possessed acceptable appearance, homogeneity, pH compatibility, satisfactory spreadability, good stability profile, and no skin irritation. Among all developed formulations, F6 emerged as the optimized formulation, exhibiting superior viscosity, excellent stability, improved spreadability, and maximum hair growth-promoting activity.

The findings indicate that the optimized polyherbal hair serum is safe, stable, effective, and suitable as a natural alternative to synthetic hair care products. The developed formulation shows strong potential for future clinical investigation, large-scale production, and commercialization within the herbal cosmetic sector.

REFERENCE

[1] Sinclair, R. (2015). Hair shedding in women: how much is too much? British Journal of Dermatology, 173(4), 846–848.

[2] Draelos, Z.D. (2010). Cosmetics and dermatologic problems and solutions. Dermatologic Therapy, 23(3), 281–288.

[3] Pandey, M.M., Rastogi, S., Rawat, A.K.S. (2013). Indian herbal drug for general healthcare. Journal of Ethnopharmacology, 150(2), 619–634.

[4] Kapoor, V.P. (2005). Herbal cosmetics for skin and hair care. Natural Product Radiance, 4(4), 306–314.

[5] Gavazzoni Dias, M.F.R. (2015). Hair cosmetics overview. International Journal of Trichology, 7(1), 2–15.

[6] Baliga, M.S., Dsouza, J.J. (2011). Amla and medicinal applications. Journal of Ethnopharmacology, 135(3), 605–622.

[7] Adhirajan, N. et al. (2003). Hair growth activity of Hibiscus rosa-sinensis. Journal of Ethnopharmacology, 88(2–3), 235–239.

[8] Surjushe, A., Vasani, R., Saple, D.G. (2008). Aloe vera therapeutic properties. Indian Journal of Dermatology, 53(4), 163–166.

[9] Wani, S.A., Kumar, P. (2018). Fenugreek bioactive compounds review. Saudi Pharmaceutical Journal, 26(7), 977–987.

[10] Biswas, K. et al. (2002). Biological activities of Neem. Current Science, 82(11), 1336–1345.

[11] Roy, R.K. et al. (2008). Pharmacological activities of Bhringraj. Phytotherapy Research, 22(8), 1025–1032.

[12] Ningappa, M.B. et al. (2008). Antioxidant properties of Curry Leaves. Food Chemistry, 106(2), 720–728.

[13] Panahi, Y. et al. (2015). Rosemary oil versus minoxidil in alopecia treatment. Skinmed Journal, 13(1), 15–21.

[14] Yu, L.X. (2008). Pharmaceutical Quality by Design concepts. AAPS Journal, 10(4), 528–531.

[15] Montgomery, D.C. (2017). Design of experiments in pharmaceutical optimization. Journal of Quality Technology, 49(3), 251–270.

[16] Stenn, K.S., Paus, R. (2001). Controls of hair follicle cycling. Physiological Reviews, 81(1), 449–494.

[17] Schneider, M.R., Schmidt-Ullrich, R., Paus, R. (2009). The hair follicle as a dynamic mini-organ. Current Biology, 19(3), R132–R142.

[18] Krause, K., Foitzik, K. (2006). Biology of the hair follicle: the basics. Seminars in Cutaneous Medicine and Surgery, 25(1), 2–10.
[19] Alonso, L., Fuchs, E. (2006). The hair cycle and stem cell regulation. Journal of Cell Science, 119(3), 391–393.
[20] Randall, V.A. (2008). Androgens and hair growth regulation. Clinical Endocrinology, 68(3), 356–365.
[21] Malkud, S. (2015). Telogen effluvium: clinical review. Journal of Clinical and Diagnostic Research, 9(9), WE01–WE03.
[22] Paus, R., Cotsarelis, G. (1999). Biology of hair follicles and hair cycle regulation. New England Journal of Medicine, 341(7), 491–497.
[23] Truong, V.L. et al. (2021). Natural products in hair growth promotion and follicle regeneration. Phytomedicine, 93, 153784.
[24] Robbins, C.R. (2012). Chemical and Physical Behavior of Human Hair. 5th Edition. Springer, New York.
[25] Gavazzoni Dias, M.F.R. (2015). Hair cosmetics: an overview. International Journal of Trichology, 7(1), 2–15.
[26] Truong, V.L., Bak, M.J., Jun, M., Jeong, W.S. (2021). Natural products and their role in hair growth promotion and follicle regeneration. Phytomedicine, 93, 153784.