



## HAIR SERUM FOR SCALP INFECTION AND HAIRFALL REDUCTION USING BHRINGRAJ AND LACTOBACILLUS ACIDOPHILUS

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**Abstract** - Scalp infections and hair fall are common dermatological problems often associated with microbial imbalance, inflammation, and weakened hair follicles. Herbal and probiotic-based formulations are gaining attention as safer and effective alternatives to synthetic treatments. The present study focuses on the development and evaluation of a novel hair 'serum formulated using Bhringraj (Eclipta alba) extract and Lactobacillus acidophilus, aimed at controlling scalp infections and reducing hair fall. Bhringraj is traditionally known for its hair growth-promoting, anti-inflammatory, and antimicrobial properties, primarily attributed to bioactive compounds such as wedelolactone and flavonoids. Lactobacillus acidophilus, a beneficial probiotic, contributes to scalp health by inhibiting pathogenic microorganisms, restoring microbial balance, and reducing inflammation through bioactive metabolites or lysates. The formulated serum is designed to act synergistically by improving scalp microbiome stability, preventing fungal and bacterial infections, strengthening hair follicles, and promoting healthy hair growth. Physicochemical characteristics, antimicrobial efficacy, and in-vitro hair-related bioassays are considered to evaluate the formulation's effectiveness. This study highlights the potential of combining herbal extracts with probiotics in cosmetic and cosmeceutical applications, offering a natural, safe, and innovative approach for managing scalp infections and hair fall.

**Keywords** - Bhringraj (Eclipta alba); Lactobacillus acidophilus; Hair serum; Scalp infection; Hair fall reduction; Probiotics; Herbal formulation; Scalp microbiome

### 1. Introduction

Hair is an important integumentary appendage with multiple functions beyond mere cosmetic considerations, such as thermoregulation and sensory perception. Hair loss (alopecia) and scalp infections such as seborrheic dermatitis, pityriasis capitis, and folliculitis are common dermatological conditions that impact the integrity and quality of life of the hair. These conditions are often associated with microbial imbalances,

inflammation, oxidative stress, hormonal imbalances, and follicular damage.

The existing conventional therapies for these conditions include corticosteroids, antifungals, minoxidil, and antibiotics. However, the concerns regarding their adverse effects, drug resistance, and cosmetic acceptability have driven the search for natural and safer alternatives. Herbal actives such as Eclipta alba (Bhringraj) have been used in Ayurvedic practices for hair growth, and probiotics such as Lactobacillus acidophilus are being investigated as microbiome modulators with antimicrobial and anti-inflammatory properties.

This review seeks to critically assess the scientific rationale for the use of Bhringraj extract and L. acidophilus in a topical hair serum formulation for the treatment of scalp infections and hair loss.

### 2. Scalp Microbiome and Pathogenesis of Scalp Disorders.

#### 2.1 Overview of Scalp Microbiome

The scalp microbiome is composed of various microorganisms, such as bacteria (Staphylococcus, Cutibacterium) and fungi (Malassezia spp.). A healthy scalp microbiome is essential for maintaining cutaneous homeostasis, lipid metabolism, and immune function. An imbalance of the scalp microbiome, or dysbiosis, has been associated with seborrheic dermatitis, dandruff, and inflammatory folliculopathies.

#### 2.2 Pathogenesis of Scalp Infections

Malassezia-related disorders: Overgrowth results in lipase activity, free fatty acid release, and inflammation.

Bacterial folliculitis: Staphylococcus aureus and coagulase-negative staphylococci cause inflammation and fragile hair shafts.



Microbiome-associated oxidative stress: Reactive oxygen species cause damage to keratinocytes and follicular cells, increasing hair shedding.

### 2.3 Mechanisms Underlying Hair Fall

Hair loss can be divided into:

Androgenetic alopecia: Hormonal miniaturization. Telogen effluvium: Stress-induced hair cycle disturbance. Inflammatory hair loss: Secondary to scalp infection and immune response. Inflammation alters the follicular stem cell microenvironment and triggers catagen entry, resulting in hair shedding.

## 3. Bhringraj (Eclipta alba): Ethnobotany, Phytochemistry, and Mechanisms

### 3.1 Traditional Uses

Bhringraj is well known in Ayurvedic medicine for its hair rejuvenating, scalp, and wound healing properties. This herb has been traditionally attributed to hair darkening and hair growth.

### 3.2 Key Phytochemicals

Wedelolactone, Demethyl wedelolactone, Flavonoids, Alkaloids Coumestans

These phytochemicals have been found to possess antioxidant, antimicrobial, anti-inflammatory, and alopecia-modulating properties.

### 3.3 Antimicrobial Activity

In vitro studies have demonstrated that Bhringraj extracts possess the ability to inhibit *Staphylococcus aureus*, *Candida albicans*, and other microbes. The mechanisms of action have been attributed to:

Cell wall disruption, Enzyme inhibition, Biofilm reduction

## 4. Lactobacillus acidophilus and Scalp Health

**4.1 Probiotics Beyond the Gut Although probiotics are known for their role in gut health, new models acknowledge the presence of a skin microbiome axis. Topical probiotics have been shown to:**

Compete with pathogenic microbes and Produce antimicrobial metabolites (bacteriocins, lactic acid) ,Modulate local immunity

**4.2 Lactobacillus acidophilus – Biological Roles L. acidophilus is a widely studied lactic acid bacterium. Relevance to scalp health includes:**

pH regulation (sustains the acidic skin environment), Bacteriocin production (inhibits *Staphylococcus*, *Malassezia*), Immunomodulation (induces antimicrobial peptides)

**4.3 Evidence in Dermatology and Scalp Disorders** Research on acne, atopic dermatitis, and dandruff indicates that probiotics can decrease colonization by pathogenic microbes and decrease inflammation. Although there is no direct evidence for scalp probiotics, there is a mechanistic rationale for exploration

## 5. Formulation Strategies for Herbal-Probiotic Hair Serum

### 5.1 Hair Serum as a Topical Delivery System

Hair serums are light, leave-on cosmetic preparations intended for direct application of bioactive molecules to the scalp and hair. Unlike shampoos, hair serums are non-rinse products, allowing for sustained contact between the active agents and the scalp. A good hair serum should have optimal viscosity, spreadability, stability, non-greasy feel, and compatibility with the scalp.

Topical delivery systems are especially useful in scalp infections and hair loss, as they circumvent systemic metabolism and allow direct action on the hair follicles and epidermal tissues. The formulation of hair serums also facilitates the use of plant extracts and probiotic-derived bioactive molecules, making them ideal for herbal-probiotic combinations.

### 5.2 Base Ingredient Selection for Herbal-Probiotic Hair Serum

The general base ingredients of herbal-probiotic hair serums are as follows:

Aqueous phase: Purified water, hydrosol

Humectants: Glycerin, propylene glycol, aloe vera gel

Solubilizers: Polysorbates for herbal extracts

Preservatives: Phenoxyethanol, potassium sorbate (compatible with probiotics or lysates)

pH adjusters: Citric acid or lactic acid (pH 4.5-5.5)

Scalp pH compatibility is essential, especially when using *Lactobacillus acidophilus* probiotics, which thrive in acidic conditions.

### 5.3 Incorporation of Bhringraj Extract

#### Extraction Method Selection

Cold maceration and hydroalcoholic extraction are preferred over other methods for Bhringraj, as wedelolactone is heat-sensitive. Hydroalcoholic mixtures of ethanol and water (50-70%) are used for the extraction of polar as well as moderately non-polar phytoconstituents.

#### \*\*Standardization\*\*

Standardization of Bhringraj extract on the basis of wedelolactone content enhances the consistency and effectiveness of the formulation. HPLC or UV-Vis spectroscopy is used for quality control analysis.

#### Role in Serum

In the serum, Bhringraj extract plays the following role: Antimicrobial action protecting against scalp pathogens, Anti-inflammatory action reducing follicular irritation, Antioxidant action preventing oxidative damage to hair follicles

### 5.4 Incorporation of *Lactobacillus acidophilus*

Forms Used in Cosmetic Formulations, *L. acidophilus* can be incorporated in various forms: Live probiotic cells (challenging stability), Heat-killed cells (paraprobiotics), Cell lysates, Fermented filtrates (postbiotics), Among these, lysates and fermented filtrates are most appropriate for cosmetic serums because of their improved stability, safety, and regulatory status.

#### Probiotic-derived bioactives:

Produce antimicrobial peptides, Modulate inflammatory pathways, Restore scalp microbiome balance, Strengthen skin barrier function

**5.5 Stability and Compatibility Issues:** The combination of herbal extracts and probiotic ingredients must be optimized. The following parameters influence stability: pH variations, Temperature, Light exposure, Preservative interactions, Encapsulation methods (liposomes, nanoemulsions) could improve stability and controlled release of actives.

## 6. Mechanisms of Action in Scalp Infection Control and Hair Fall Reduction

### 6.1 Antimicrobial Mechanisms

#### Bhringraj- Mediated Action

The phytochemical constituent wedelolactone acts by disrupting microbial cell membranes, interfering with enzymatic function, and affecting nucleic acid synthesis. Inhibitory effects have been observed against *Staphylococcus aureus*, *Candida albicans*, and dermatophytes, *L. acidophilus*-Mediated Action

The probiotic metabolites, lactic acid, and bacteriocins exert antimicrobial effects by: Competitive exclusion, pH reduction, Inhibition of biofilm formation. These mechanisms, in combination, contribute to the reduction of scalp microbial load and the recurrence of infection

### 6.2 Anti-Inflammatory Pathways

Chronic scalp infections can lead to follicular miniaturization and hair fall due to chronic inflammation. Bhringraj extracts inhibit pro-inflammatory cytokines (TNF- $\alpha$ , IL-6) and reduce COX-2 expression. Probiotic lysates also modulate the immune system by increasing the production of anti-inflammatory media

### 6.3 Antioxidant Defense

Follicular keratinocytes and dermal papilla cells are affected by oxidative stress. Flavonoids and coumestans in Bhringraj work as antioxidants by scavenging ROS, and probiotic metabolites trigger the body's natural production of antioxidant enzymes like superoxide dismutase.

### 6.4 Hair Growth and Follicular Stimulation

Experimental research shows that Bhringraj extracts stimulate: Anagen phase extension, Dermal papilla cell proliferation, Increased blood flow to the hair follicles, Probiotic fractions have an indirect effect on hair growth by decreasing inflammation and providing a favorable scalp environment that is conducive to hair follicle regeneration

## 7. Preclinical Evidence Supporting the Use of Bhringraj and *Lactobacillus acidophilus*

### 7.1 In-Vitro Antimicrobial Studies on Bhringraj

In-vitro studies have been conducted to establish the antimicrobial properties of *Eclipta alba* extracts against scalp-related pathogens. The ethanolic and hydroalcoholic extracts of

Bhringraj have been found to possess strong inhibitory action against Gram-positive bacteria such as *Staphylococcus aureus* and *Staphylococcus epidermidis*, which are known to cause folliculitis and secondary scalp infections .

Antifungal properties have also been established against *Candida albicans* and dermatophytes. Although *Malassezia* species are lipid-dependent and difficult to culture, there is indirect evidence that the phytoconstituents of Bhringraj have the ability to inhibit fungal growth by interfering with membrane sterols and reducing the inflammatory lipid by-products

The standard antimicrobial tests employed are: Agar well diffusion, Disc diffusion, Minimum inhibitory concentration (MIC) determination

### 7.2 Hair Growth-Promoting Activity of Bhringraj

Animal and cellular experiments have demonstrated the hair growth-promoting activity of *Eclipta alba*. Topical application of Bhringraj extract in animal models has been demonstrated to: Accelerate the transition of hair follicles from telogen to anagen phase, Increase hair density and length, Enhance follicular size and depth.

Histological examination showed enhanced proliferation of dermal papilla cells and improved follicular morphology. This is due to the presence of active phytoconstituents like wedelolactone and flavonoids, which activate cellular signaling pathways responsible for follicular regeneration

### 7.3 Antioxidant and Anti-Inflammatory Studies

Oxidative stress is one of the major factors for the aging of hair follicles and inflammatory hair loss. Bhringraj extracts have been found to have potent antioxidant properties in tests like: DPPH radical scavenging assay, ABTS assay, Ferric reducing antioxidant power (FRAP) assay.

Anti-inflammatory activity has been validated by the inhibition of nitric oxide production and downregulation of pro-inflammatory cytokines in macrophage cell lines. This is a critical requirement for the reduction of scalp inflammation caused by chronic dandruff and microbial infections.

### 7.4 Probiotic Activity of *Lactobacillus acidophilus* in Skin Health

*Lactobacillus acidophilus* has long been recognized for its benefits in gut health, but it has also been found to have promising skin health benefits. In vitro studies have revealed that *L. acidophilus* secretes: Lactic acid (helps to maintain the acidic pH of the skin), Bacteriocins (target pathogenic

bacteria), Short-chain fatty acids with anti-inflammatory properties.

Probiotic culture fluid and cell lysates have been found to significantly inhibit the growth of *Staphylococcus aureus* and suppress inflammation in keratinocyte cultures.

### 7.5 Role of Probiotic Lysates and Postbiotics

The use of probiotic lysates and postbiotics in cosmetics has gained popularity because of their enhanced stability and safety. It has been observed that *L. acidophilus* probiotic lysates: Improve skin barrier function, Stimulate the expression of antimicrobial peptides, Inhibit pathogen binding to epithelial cells.

## 8. Synergistic Effects of Herbal-Probiotic Combinations

### 8.1 Concept of Synergy in Cosmeceuticals

Synergy is the phenomenon where the sum of the effects of two agents is greater than the sum of their individual effects. Herbal probiotic combinations are being increasingly investigated for their potential use in cosmeceutical formulations because of their synergistic mechanisms of action.

### 8.2 Mechanistic Synergy Between Bhringraj and *L. acidophilus*

#### The combination of both:

Provides dual antimicrobial activity: Plant phytochemicals + Probiotic metabolites, Provides enhanced anti-inflammatory activity: Cytokine inhibition and immune system modulation. Repairs the microbiome: Inhibits pathogens and provides beneficial microbial support. Probiotics further increase the bioavailability of herbal compounds by enzymatic conversion.

### 8.3 Advantages Over Conventional Treatments

Herbal probiotic serums have been found to have an advantage over conventional antifungal agents and hair growth medications because they:

Have fewer side effects, Do not contribute to antimicrobial resistance, Promote long-term scalp health. This makes them potential alternatives in the sustainable development of cosmetics.

## 9. In-Vitro Evaluation Methods for Hair Serum Formulations

### 9.1 Physicochemical Evaluation



pH measurement, Viscosity measurement, spreadability test, Stability studies (temperature, centrifugation)

### 9.2 Antimicrobial Assays

Agar well diffusion test against *S. aureus* and *Candida albicans*, Time-kill studies, Biofilm inhibition tests

### 9.3 Cell-Based Hair Growth Assays

Dermal papilla cell proliferation assays, Keratinocyte viability (MTT assay), Anti-inflammatory cytokine profiling. These tests help to scientifically validate the efficacy of the formulation.

## 10. Clinical Relevance of Herbal-Probiotic Hair Serums

### 10.1 Limitations of Conventional Therapies

The conventional treatment of scalp infections and hair loss is dominated by antifungal drugs (ketoconazole), corticosteroids, antibiotics, and hair growth promoters like minoxidil. Although successful, long-term use of these drugs can cause side effects such as irritation, dryness, hormonal imbalances, rebound dandruff, and microbial resistance.

Moreover, most conventional drugs are designed to provide symptomatic relief rather than achieve scalp homeostasis. This has led to a growing demand for more natural and probiotic-friendly alternatives, especially for long-term cosmetic applications.

### 10.2 Advantages of Herbal-Probiotic Interventions

Herbal-probiotic hair serums have a multi-targeted approach: Inhibit microbial infections without harming beneficial flora, Decrease inflammation and oxidative stress, Induce follicular wellness and hair growth, Enhance scalp barrier integrity. Bhringraj and *L. acidophilus* combination has therapeutic and prophylactic properties, making them ideal for long-term scalp condition

### 10.3 Evidence from Related Clinical and Cosmetic Studies

Herbal hair oils and tonics, Probiotic-containing dermatological products

provide evidence for their efficacy. Probiotic dermatological products have been shown to reduce inflammation, pathogenic colonization, and symptoms of dermatitis and dandruff-like disorders.

## 11. Safety, Toxicity, and Biocompatibility Concerns

### 11.1 Safety Profile of Bhringraj

*Eclipta alba* has been traditionally used externally and internally for various medicinal purposes. The toxicological analysis of *E. alba* reveals: Low dermal toxicity, Lack of mutagenicity, High biocompatibility with skin tissues

However, quality control and standardization of *E. alba* are important to prevent contamination and differences in phytochemical composition.

### 11.2 Safety of *Lactobacillus acidophilus* in Topical Formulations

*L. acidophilus* has been declared Generally Recognized as Safe (GRAS) for use in food and cosmetic products. Topical probiotic formulations overcome the potential hazards of live microbial agents, including infection and instability. Clinical dermatology studies demonstrate that topical probiotic formulations are. Non-disruptive of skin barrier function. Tolerated in various skin types. Sensitivities and irritations reduced

### 11.3 Preservatives and Biocompatibility Concerns

Preservatives used in topical formulations should be safe against microbes without deactivating probiotic compounds. Mild and broad-spectrum preservatives compatible with probiotic lysates are desirable.

Patch testing and skin irritation studies are necessary before clinical application.

## 12. Challenges in Development of Herbal-Probiotic Hair Serums

### 12.1 Stability Challenges

Degradation of phytochemicals, Loss of probiotic metabolite activity, pH drift during storage, Advanced delivery systems such as nanoemulsions and encapsulation can improve stability.

### 12.2 Standardization and Quality Control

Batch-to-batch variability in herbal extracts remains a significant challenge. Standardization based on marker compounds such as wedelolactone is recommended.

### 12.3 Consumer Acceptance and Regulatory Complexity

Herbal-probiotic products need to strike a balance between: Scientific credibility, Sensory appeal, Regulatory compliance,



Clear labeling and evidence-based claims are essential for market success.

### **13. Regulatory Aspects and Quality Assurance in Herbal-Probiotic Hair Serums**

#### **13.1 Regulatory Classification**

Herbal-probiotic hair serums can be broadly categorized as cosmetic or cosmeceutical products, depending on their claims. In India, these products are governed by the Drugs and Cosmetics Act, 1940, whereas internationally, they come under the cosmetic regulations of the FDA (USA)

Claims regarding the treatment and cure of diseases are limited; hence, the formulation should be categorized as a scalp health-enhancing and hair fall-reducing agent, not a therapeutic drug.

#### **13.2 Good Manufacturing Practices (GMP)**

GMP is essential for ensuring the safety and quality of the product. The important points are: Validation of plant materials, Microbial quality testing. Analysis for heavy metals and pesticide residues, Stability and shelf-life studies. In the case of probiotic-derived compounds, the endotoxin content and microbial contamination should be carefully regulated.

#### **13.3 Quality Control Parameters**

Quality assurance includes: Standardization of Bhringraj extract (wedelolactone content), Validation of probiotic lysate activity, Physicochemical consistency, Packaging compatibility testing

### **14. Industrial and Market Relevance of Herbal-Probiotic Hair Serums**

#### **14.1 Growing Demand for Natural and Microbiome-Friendly Product**

Consumer awareness regarding ingredient safety and sustainability has led to increased demand for plant-based and microbiome-friendly cosmetics. Herbal-probiotic hair serums are in line with the current market trends that focus on: Clean beauty, Ayurvedic heritage, Science-backed formulations.

### **15. Conclusion**

The combination of Bhringraj (*Eclipta alba*) and *Lactobacillus acidophilus* in a hair serum appears to be a promising, natural, and scientifically validated approach for the treatment of scalp infections and hair fall. Bhringraj has strong antimicrobial, antioxidant, and hair growth-stimulating actions, while *L. acidophilus* has the ability to improve the balance of the scalp

microbiota, inhibit the growth of pathogens, and modulate inflammation.

The combination of phytochemicals and probiotic-derived compounds has several advantages over traditional synthetic drugs, including reduced side effects, lack of resistance, and long-term benefits for scalp health. The preclinical data available strongly supports their efficacy, and the emerging area of cosmetic science emphasizes the importance of microbiome-targeted hair care.

Despite the difficulties in terms of stability, standardization, and regulatory issues, there are feasible solutions available in formulation science and delivery systems. In conclusion, hair serums containing herbal and probiotic ingredients have a great potential in the area of cosmeceutical development.

### **16. Future Prospects**

Future studies should concentrate on:

Clinical trials for efficacy in scalp infections and hair loss. Delivery systems (nanoemulsion, encapsulation). Scalp microbiome analysis using omics techniques. Long-term safety and user compliance trials.

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