JOURNAL OF PHARMA INSIGHTS AND RESEARCH ISSN NO. 3048-5428

RESEARCH ARTICLE

Development and Physicochemical Evaluation of a Polyherbal Dual-Action Shampoo for Hair Coloring and Conditioning

Suneetha Yaparthi*[1], Yasmeen Begum M[2], Praharsha I[2], Naga Renuka K[2]

[1] *Professor, Department of Pharmaceutical Chemistry, Dr. Samuel George Institute of Pharmaceutical Sciences, Markapur, Andhra Pradesh, India*
[2] *UG Scholar, Department of Pharmaceutical Chemistry, Dr. Samuel George Institute of Pharmaceutical Sciences, Markapur, Andhra Pradesh, India*

Publication history: Received on 6th October 2025; Revised on 21st October 2025; Accepted on 24th October 2025

Article DOI: 10.69613/62xn7985

Abstract: The cosmetic formulations have witnessed a paradigm shift towards natural molecules, driven by raising concerns regarding the dermatological and systemic toxicity associated with synthetic hair dyes and surfactants. Conventional hair coloring systems, frequently laden with para-phenylenediamine (PPD) and ammonia, are implicated in contact dermatitis, cytotoxicity, and structural damage to the hair keratin. This study explains about the formulation and evaluation of a novel polyherbal shampoo designed to function synergistically as a natural hair colorant and a conditioner, thereby eliminating the need for multi-step hair care regimens. The formulation incorporates *Lawsonia inermis* and *Indigofera tinctoria* as primary chromophores, augmented by the anthocyanins of Hibiscus rosa-sinensis, while conditioning is achieved through the bioactive mucilage and phytosterols of *Aloe barbadensis*, *Eclipta alba*, and *Trigonella foenum-graecum*. Physicochemical characterization revealed that the optimized formulation possesses a slightly acidic pH compatible with the scalp's acid mantle, alongside appropriate rheological properties ensuring ease of application and spreadability. Spectrophotometric analysis confirmed the effective deposition of lawsone and indigotin on hair shafts, offering a safe spectrum of brown to black hues tailored by the ratio of botanical dyes. Moreover, the inclusion of saponin-rich botanicals facilitated adequate foaming and cleansing action without stripping natural oils. Accelerated stability studies indicated that the formulation maintains its organoleptic and physicochemical integrity over a thirty-day storage period. These results suggest that the developed herbal shampoo offers a viable, non-toxic alternative to synthetic counterparts, effectively combining aesthetic coloring with therapeutic hair care.

Keywords: Polyherbal formulation; Natural chromophores; *Lawsonia inermis*; Hair keratin; Physicochemical stability.

1. Introduction

Hair care represents a significant segment of the personal care industry, with hair coloring and conditioning being the two most prevalent cosmetic procedures. However, the reliance on synthetic formulations has raised substantial safety concerns. Oxidative dyes, which dominate the market, typically contain precursors such as para-phenylenediamine (PPD), p-toluenediamine, and resorcinol, coupled with alkalizing agents like ammonia. Epidemiological and toxicological data suggest that frequent exposure to these compounds is linked to severe allergic contact dermatitis, scalp irritation, and potential mutagenic effects [1]. Furthermore, the oxidative mechanism involved in synthetic dyeing disrupts the disulfide bonds within the hair cortex, leading to increased porosity, brittleness, and loss of tensile strength [2].

Parallel to the issues with dyes, commercial conditioners often utilize silicones (e.g., dimethicone) and quaternary ammonium compounds to impart temporary smoothness. While effective, these synthetic conditioning agents can accumulate on the hair shaft, causing buildup that weighs down hair and potentially disrupts the scalp microbiome [3].

Consequently, there is an increasing consumer demand for "green" cosmetics that utilize biodegradable, renewable, and non-toxic ingredients. Ayurveda and traditional systems of medicine offer a rich repository of botanical agents with proven efficacy in hair care. *Lawsonia inermis* (Henna) has been historically utilized for its lawsone content, a naphthoquinone pigment that binds to hair keratin to provide reddish-orange hues [4]. *Indigofera tinctoria* (Indigo), containing the precursor indican, produces a blue dye that, when combined with henna, can yield shades ranging from dark brown to black [5]. Apart from coloring, botanicals such as *Aloe barbadensis* (Aloe vera), *Eclipta alba* (Bhringraj), and *Trigonella foenum-graecum* (Fenugreek) are renowned for their high mucilage and protein content, which provide deep conditioning, strengthen the hair shaft, and soothe the scalp [6].Despite the individual popularity of these ingredients, there is a paucity of literature on formulations that successfully integrate natural dyeing and cleansing-

* Corresponding author: Suneetha Yaparthi

conditioning properties into a single stable product. The present research aims to bridge this gap by formulating a dual-function polyherbal shampoo. This study evaluates the synergistic potential of selected herbal extracts to provide durable natural color while simultaneously improving hair texture and manageability, validated through rigorous physicochemical and stability testing.

2. Materials and Methods

2.1. Preparation of Plant Materials

The formulation utilized a selection of botanicals known for their chromatic and therapeutic properties. *Lawsonia inermis* leaves and *Indigofera tinctoria* leaves were sourced for their dyeing capability. *Hibiscus rosa-sinensis* petals were selected for their dual role as a mild colorant and conditioner. For conditioning and scalp health, *Aloe barbadensis* (fresh gel), *Eclipta alba* (whole plant), and *Trigonella foenum-graecum* (seeds) were employed. Natural surfactants were derived from *Sapindus mukorossi* (Reetha) and *Acacia concinna* (Shikakai) to ensure a gentle cleansing action free from sulfated surfactants like Sodium Lauryl Sulfate (SLS). Essential oils of Rosemary and Lavender were procured to serve as functional fragrances and mild preservatives.

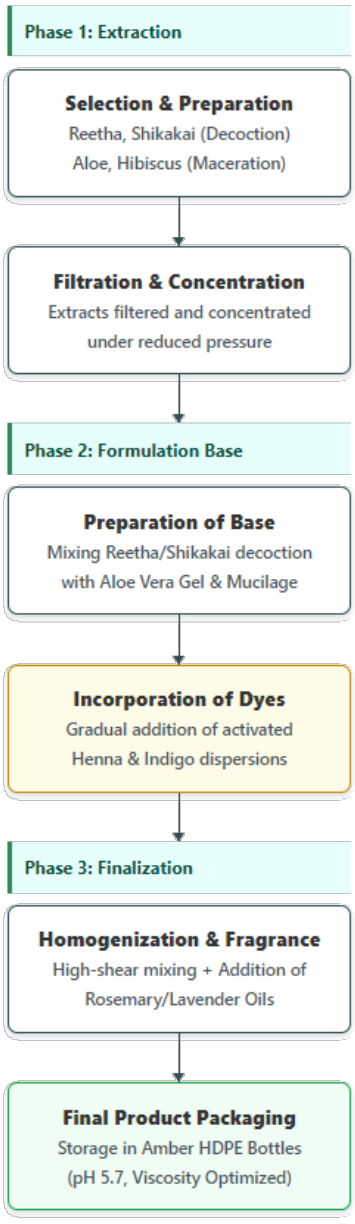

Figure 1. Process for Preparation of Polyherbal Shampoo Preparation

2.2. Procedure for Extraction

To maximize the yield of phytoconstituents, specific extraction methods were tailored to each plant material.

2.2.1. Aqueous Decoction

Hard plant materials, specifically the dried fruits of *Sapindus mukorossi*, pods of *Acacia concinna*, and seeds of *Trigonella foenum-graecum*, were subjected to aqueous decoction. The materials were coarsely powdered and boiled in distilled water at a controlled temperature to extract saponins and mucilage without thermal degradation. The resulting decoction was filtered through a muslin cloth and subsequently concentrated under reduced pressure to achieve a viscous consistency appropriate for a shampoo base [7].

2.2.2. Maceration and Gel Extraction

Fresh *Aloe barbadensis* leaves were washed, and the outer rind was carefully peeled to harvest the inner parenchymal gel. This gel was homogenized to obtain a uniform consistency. Soft plant parts, including *Hibiscus* petals and *Eclipta alba*, underwent cold maceration in distilled water for 24 hours to extract heat-sensitive bioactives, followed by filtration.

2.3. Formulation of the Herbal Shampoo

The shampoo base was established by combining the concentrated decoctions of Reetha and Shikakai, which provide the primary foaming and cleansing mechanism.

Table 1. Composition of the Polyherbal Dual-Action Shampoo (per 100 mL)

Ingredient	Botanical Source	Quantity (% w/v)	Role in Formulation
Reetha Decoction	*Sapindus mukorossi*	30.0	Natural Surfactant / Cleanser
Shikakai Decoction	*Acacia concinna*	20.0	Natural Surfactant / Detangler
Aloe Vera Gel	*Aloe barbadensis*	15.0	Humectant / Soothing Agent
Henna Extract	*Lawsonia inermis*	10.0	Natural Dye (Lawsone source)
Indigo Extract	*Indigofera tinctoria*	10.0	Natural Dye (Indican source)
Hibiscus Extract	*Hibiscus rosa-sinensis*	5.0	Conditioner / Color Enhancer
Bhringraj Extract	*Eclipta alba*	5.0	Hair Growth Promoter
Fenugreek Extract	*Trigonella foenum-graecum*	4.0	Conditioning Mucilage
Rosemary Oil	*Rosmarinus officinalis*	0.5	Fragrance / Antioxidant
Lavender Oil	*Lavandula angustifolia*	0.5	Fragrance / Antimicrobial
Distilled Water	—	q.s. to 100 mL	Vehicle / Solvent

To this surfactant base, the *Aloe vera* gel and homogenized extracts of *Bhringraj* and *Fenugreek* were incorporated under continuous low-shear stirring to prevent excessive foaming during the mixing process. The coloring agents—fine powders of Henna and Indigo—were pre-dispersed in a small quantity of warm water to activate the dye precursors (release of lawsone and hydrolysis of indican) before being integrated into the base. This step is critical to ensure uniform color dispersion and prevent grittiness in the final product. Finally, Rosemary and Lavender essential oils were added at a concentration of 0.5% v/v to impart fragrance and enhance antimicrobial stability. The final formulation was homogenized, adjusted to the required volume with distilled water, and stored in amber-colored high-density polyethylene (HDPE) bottles to prevent photodegradation of the natural dyes [8].

2.4. Physicochemical Evaluation

The prepared shampoo underwent comprehensive evaluation to ensure safety, efficacy, and compliance with standard quality parameters for cosmetic formulations.

2.4.1. Determination of pH

The pH of the formulation is a critical parameter influencing scalp tolerance and hair cuticle behavior. A 10% v/v solution of the shampoo was prepared in distilled water, and the pH was measured using a calibrated digital pH meter. Ideally, the pH should mimic the natural acidity of the scalp (4.5–6.0) to prevent cuticle swelling and irritation [9].

2.4.2. Viscosity

Viscosity determines the product's flow characteristics, influencing ease of removal from the container and spreadability on the hair. The viscosity was measured using a Brookfield viscometer at room temperature. Readings were taken at various shear rates to understand the flow behavior, ensuring the product is neither too fluid nor too viscous.

2.4.3. Foam Stability and Detergency

Foaming ability was evaluated using the cylinder shake method. A 50 ml solution of the shampoo (1%) was placed in a graduated cylinder and shaken vigorously for 1 minute. The foam volume was recorded immediately and at 5-minute intervals to assess foam stability. While foam volume does not directly correlate with cleaning efficiency, it is a significant psychometric attribute for consumer acceptance.

2.4.4. Wetting Time

The wetting efficiency, which indicates the surfactant's ability to reduce surface tension and penetrate the hair shaft, was determined using the canvas disc method. A cotton canvas disc of standard diameter was placed on the surface of the shampoo solution, and the time taken for the disc to sink was recorded. A lower wetting time correlates with faster cleansing action.

2.4.5. Conditioning and Detangling Efficiency

The conditioning effect was qualitatively assessed via the combability test. Standardized hair swatches were washed with the herbal shampoo, and the ease of combing (wet and dry) was compared against a control swatch washed with a non-conditioning surfactant solution. Parameters such as friction reduction and smoothness were noted.

2.4.6. Determination of Coloring Efficiency

The deposition of color was evaluated both visually and instrumentally. White wool yarn and bleached human hair swatches were treated with the shampoo for a fixed duration. The color uptake was quantified using UV-Visible spectrophotometry. The absorption maxima were analyzed at 480 nm (characteristic of Lawsone) and 610 nm (characteristic of Indigotin) to estimate the dye concentration deposited on the substrate [10].

2.5. Accelerated Stability Studies

To predict the shelf-life, the formulation was subjected to accelerated stability testing as per ICH guidelines. Samples were stored at elevated temperatures (40°C ± 2°C) and room temperature for a period of 30 days. At regular intervals, the samples were inspected for physical instability markers such as phase separation, precipitation, color fading, or fermentation (foul odor).

3. Results and Discussion

3.1. Physicochemical Properties

The physicochemical analysis of the formulated herbal shampoo indicated favorable characteristics for topical application. The pH was recorded at 5.7, which lies within the ideal range for maintaining the scalp's acid mantle. This slightly acidic environment is crucial for keeping the hair cuticle flat, thereby enhancing shine and reducing friction, while also providing a stable medium for the activity of the natural dyes [11].

The viscosity assessment revealed a consistency in the range of 3,000 to 6,000 cP. This rheological profile characterizes a medium-thick fluid that allows for controlled dispensing and uniform application across the scalp without running off prematurely. The use of mucilaginous extracts from *Aloe vera* and *Fenugreek* contributed naturally to this viscosity, negating the need for synthetic thickeners.

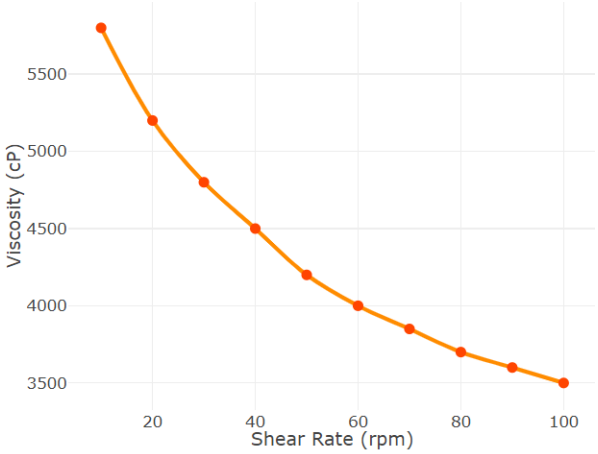

Figure 2. Rheological Behaviour showing Pseudoplastic (shear-thinning) flow

3.2. Foaming and Cleansing Ability

Despite the absence of sulfated surfactants, the formulation demonstrated robust foaming capability, with a foam retention of approximately 90% after 5 minutes.

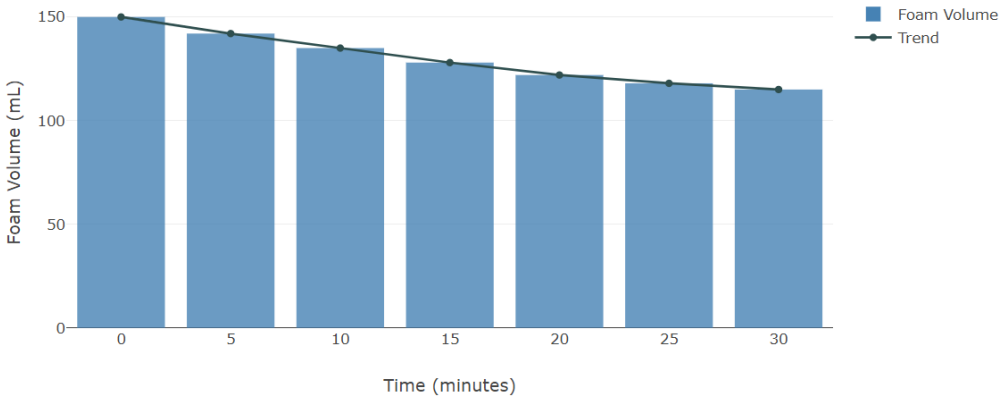

Figure 3. Foam retention over time

This stability is attributed to the high saponin content in *Sapindus mukorossi* and *Acacia concinna*. The natural surfactants lowered the surface tension effectively, as evidenced by the wetting time (30–60 seconds) and the ink dispersion test, which showed no re-deposition of dirt particles. This suggests that the shampoo effectively suspends soil and sebum, facilitating their removal during rinsing.

3.3. Evaluation of Coloring Efficacy

The primary objective of the dual-function formulation was to achieve effective hair coloring. Visual inspection of treated hair swatches revealed a significant shift in color from grey/white to a deep brown/black shade after three consecutive applications. This cumulative coloring effect is characteristic of natural dyes, which rely on the coating and penetration of the hair cuticle layers rather than the oxidative chemical reaction within the cortex used by synthetic dyes.

UV-Visible spectrophotometric analysis corroborated the visual findings. The absorption spectrum showed distinct peaks at 480 nm and 610 nm. The absorbance values for Lawsone ranged between 0.9 and 1.2 AU. This indicates a substantial deposition of the red-orange pigment, which acts as a base coat, adhering to the keratin protein. The Absorbance values for Indigotin ranged between 0.6 and 0.95 AU. The presence of Indigotin confirms the successful release of the blue dye molecule, which neutralizes the orange tone of henna to produce the desired dark hues.

Table 2. Results for evaluation tests

Evaluation Parameter	Observation/Result	Inference
Physicochemical Properties	pH: 5.7; Viscosity: Medium (3,000–6,000 cP)	Matches the scalp's natural acidic mantle, preventing cuticle damage. Consistency allows easy application without dripping.
Cleansing Efficacy	Foam retention: ~90% after 5 min; Wetting time: 30–60 sec	High saponin content from *Reetha* ensures effective dirt removal and lathering comparable to synthetic surfactants.
Coloring Efficiency	Visual: Dark brown/black shift; UV-Vis: Peaks at 480 nm (Lawsone) & 610 nm (Indigotin)	Confirming deposition of both red and blue pigments on the hair shaft, achieving the target dark shade naturally.
Conditioning Effect	Reduced fly-aways; Improved wet/dry combability	Mucilage from *Aloe* and *Fenugreek* forms a protective film, reducing static and mimicking the effect of silicones.
Stability Profile	No phase separation; No microbial growth; Stable pH (30 days at 40°C)	Essential oils acted as effective preservatives; the emulsion system remained robust under stress conditions.

3.4. Conditioning and Hair Texture

Subjective evaluation of hair texture post-wash indicated a marked improvement in hair manageability. The "fly-away" phenomenon, often caused by static electricity in dry hair, was minimized. This antistatic and conditioning effect can be attributed to the film-forming properties of *Aloe vera* polysaccharides and the coating action of *Hibiscus* mucilage. Unlike silicone-based conditioners that may cause long-term buildup, these botanical agents provided a soft, non-greasy finish, improving the tactile quality of the hair strands.

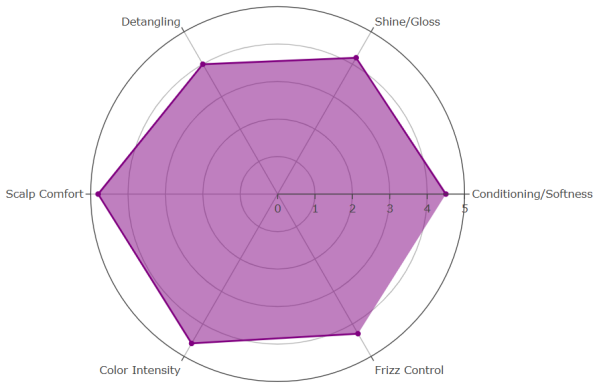

Figure 5. Evaluation of Sensory Feel & Conditioning of the Prepared Shampoo

3.5. Stability Studies

The 30-day accelerated stability study demonstrated the robustness of the formulation. There was no evidence of phase separation or creaming, indicating a stable emulsion/suspension system. The preservation of the formulation was effective, as no microbial growth or development of foul odors was detected. Moreover, the color intensity of the product itself remained consistent, suggesting that the amber packaging and the antioxidant properties of the essential oils effectively protected the photosensitive natural dyes from degradation.

4. Conclusion

A dual-action polyherbal shampoo was successfully formulated that addresses two major consumer needs: safe hair coloring and effective conditioning. The formulation offers a holistic alternative to synthetic products by synergizing the dyeing potential of *Lawsonia inermis* and *Indigofera tinctoria* with the cleansing and conditioning properties of traditional herbs. The physicochemical evaluation confirms that the shampoo is scalp-friendly, possesses good cleansing and foaming properties, and delivers significant

coloring efficacy without the use of PPD or ammonia. The stability data further supports its potential for commercial viability. This product can be a promising candidate in the growing market of green cosmeceuticals.

Compliance with ethical standards

Acknowledgements

The authors would like to express their sincere gratitude to the management and faculty of the YSRF – Dr. Yellapragada Subba Rao Research Centre, Markapur, Andhra Pradesh, India, for providing the necessary laboratory facilities, chemicals, and instrumental support required to carry out this experimental work.

Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. This study was conducted solely for academic and scientific purposes.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors. All evaluations, including physicochemical properties, dyeing efficiency, and conditioning effects, were conducted using *ex vivo* hair swatches and standard laboratory apparatus.

Statement of informed consent

Not applicable. The study did not involve human participants, surveys, or clinical trials; therefore, informed consent was not required.

References

[1] Kondle R, Pathapati RM, Sudi P, Patil S. Paraphenylenediamine: Blackening more than just hair. J Clin Toxicol. 2012;2(13):1-4.

[2] Guerra-Tapia A, Gonzalez-Guerra E. Hair Cosmetics: Dyes. Actas Dermosifiliogr. 2014;105(9):833-839.

[3] Gavazzoni Dias MF. Hair cosmetics: an overview. Int J Trichology. 2015;7(1):2-15.

[4] Chaudhary G, Goyal S, Poonia P. Lawsonia inermis Linnaeus: a phytopharmacological review. Int J Pharm Sci Drug Res. 2010;2(2):91-98.

[5] Chanayath N, Lhieochaiphant S, Phutrakul S. Pigment extraction techniques from the leaves of Indigofera tinctoria and its use for dyeing silk. CMU J. 2002;1(2):149-160.

[6] Soni A, Gupta A. Formulation and evaluation of herbal shampoo containing extracts of Aloe vera and Bhringraj. J Drug Deliv Ther. 2021;11(4-S):123-126.

[7] Al Badi K, Khan SA. Formulation, evaluation and comparison of the herbal shampoo with the commercial shampoos. Beni-Suef Univ J Basic Appl Sci. 2014;3(4):301-305.

[8] Mainkar AR, Jolly CI. Formulation of natural shampoos. Int J Cosmet Sci. 2001;23(1):59-62.

[9] Gavazzoni Dias MF, de Almeida AM, Cecato PM, Adriano AR, Pichler J. The shampoo pH can affect the hair: myth or reality? Int J Trichology. 2014;6(3):95-99.

[10] Yusuf M, Shabbir M, Mohammad F. Natural colorants: Historical, processing and sustainable prospects. Nat Prod Bioprospect. 2017;7(1):123-145.

[11] Robbins CR. Chemical and Physical Behavior of Human Hair. 5th ed. Berlin: Springer; 2012