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FORMULATION AND EVALUATION OF A POLYHERBAL SHAMPOO INCORPORATING SEVEN AYURVEDIC BOTANICAL EXTRACTS

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ABSTRACT

Herbal alternatives to traditional shampoos, which frequently contain synthetic surfactants linked to hair damage and scalp irritation, have gained popularity due to the growing demand for sustainable and natural personal care products. The present study aimed to formulate and evaluate a liquid polyherbal shampoo incorporating aqueous extracts of seven Ayurvedic medicinal plants: *Hibiscus rosa-sinensis*, *Eclipta alba*, *Phyllanthus emblica*, *Acacia concinna*, *Sapindus mukorossi*, *Trigonella foenum-graecum*, and *Oryza sativa*. These plants were chosen because of their traditional use and documented phytochemical qualities that are good for the health of the hair and scalp. Aqueous extracts were prepared by decoction method and subjected to preliminary phytochemical screening. Three formulations (F1, F2, and F3) were developed using varying concentrations of herbal extracts, with sodium laury sulfate serving as a co-surfactant and sodium benzoate as a preservative. The formulations were assessed for pH, viscosity, foam volume and stability, dirt dispersion, surface tension, wetting time, and total solid content. All formulations demonstrated acceptable physicochemical characteristics and were compatible with standard shampoo quality requirements. The pH ranged from 5.9 to 6.2 suggesting that it is suitable for scalp application. Among the tested batches, F3 exhibited the most favorable performance, showing optimal viscosity, improved foam characteristics, reduced surface tension, quicker

wetting time, and appropriate solid content. The observed results suggest a synergistic contribution of the herbal constituents toward cleansing, conditioning, and hair-protective benefits. The optimised formulation has the potential to be a biodegradable Ayurvedic shampoo and should be further investigated through clinical evaluation, safety evaluations, and stability investigations.

KEYWORDS: Polyherbal shampoo; Saponin-based surfactants; Biodegradable hair care; Hair follicle stimulation; *Hibiscus rosa-sinensis*, *Eclipta alba*, *Phyllanthus emblica*, *Acacia concinna*, *Sapindus mukorossi*, *Trigonella foenum-graecum*, and *Oryza sativa.*

INTRODUCTION

Hair serves as a fundamental expression of identity across diverse global cultures. The Ayurvedic tradition of the Indian subcontinent embodies an empirically refined approach to hair maintenance, drawing upon a botanical pharmacopoeia developed over approximately three millennia.

Shampoo represents the most widely used topical hair hygiene preparation, intended to eliminate excess sebum, environmental particulates, and cosmetic residue from the scalp and hair shaft. Current synthetic shampoos predominantly utilize anionic surfactants - notably sodium lauryl sulfate (SLS) and sodium laureth sulfate (SLES) to achieve their cleansing and foaming characteristics. Nonetheless, prolonged use of these surfactants is linked to the impairment of the scalp lipid barrier, elevation of the hair cuticle, heightened transepidermal water loss, and the manifestation of irritant contact dermatitis.[1]

The human hair fibre comprises three concentric layers: the cuticle (an overlapping keratinised sheath), the cortex (the principal structural zone containing melanin and fibrous keratin bundles), and the medulla (a central core contributing to mechanical rigidity). Because shampoo interacts directly with the cuticle, alkaline preparations cause cuticle scale elevation, resulting in diminished lustre and increased fibre fragility. Maintaining a mildly acidic formulation pH aligned with the scalp's acidic mantle (pH 4.5-5.5) is therefore a primary quality criterion in shampoo development.[2]

The worldwide market for herbal cosmetics, estimated to be valued between USD 85-99 billion in the year 2024, is anticipated to maintain a compound annual growth rate (CAGR) ranging from 5% to 13% through the year 2030 across various market segments.[3] Polyherbal

formulations provide synergistic interactions of phytochemicals derived from botanical extracts, wherein the cumulative biological activity of an array of secondary metabolites often exceeds the effectiveness of individual plant constituents.[4]

In the context of Ayurvedic cosmeceuticals, seven botanicals - *Hibiscus rosa-sinensis, Eclipta alba, Phyllanthus emblica, Acacia concinna, Sapindus mukorossi, Trigonella foenum-graecum,* and *Oryza sativa* were selected on the basis of their well-characterised phytochemical profiles and established roles in traditional Ayurvedic hair care.[5,8] This study reports the comparative development and systematic physicochemical evaluation of three shampoo formulation batches to identify an optimised plant-based prototype.

MATERIAL AND METHODS

Plant Material Procurement and Authentication

Dried plant materials *H. rosa-sinensis* flowers, *E. alba* aerial parts, *P. emblica* fruits, *A. concinna* pods, *S. mukorossi* pericarp, *T. foenum-graecum* seeds, and *O. sativa* grains were procured from a certified Ayurvedic supplier, Gandhinagar, Gujarat. Botanical identity was confirmed by macroscopic and microscopic examination at the Department of Pharmacognosy, K. B. Raval College of Pharmacy. Analytical-grade SLS, sodium benzoate, and citric acid were obtained from authorised chemical suppliers. Double-distilled water served as the solvent throughout.

The botanical characteristics and functional roles of the selected plant materials are presented in Table 1.

Table 1: Botanical characteristics and functional roles of plant materials used in formulation[4,8]

Common Name	Botanical Name	Family	Part Used	Key Phytochemicals	Therapeutic Role
Hibiscus	*Hibiscus rosa-sinensis L.*	Malvaceae	Flowers	Flavonoids, mucilage, amino acids, anthocyanins	Conditioning; hair growth promotion
Bhringraj	*Eclipta alba (L.) Hassk.*	Asteraceae	Aerial parts	Wedelolactone, eclalbatin, ecliptine, flavonoids	Anti-hair fall; anagen phase stimulation
Amla	*Phyllanthus emblica L.*	Phyllanthaceae	Fruits	Tannins, ascorbic acid, ellagic acid, gallic acid	Antioxidant; anti-greying; pH buffering
Shikakai	*Acacia concinna (Willd.) DC.*	Fabaceae	Pods	Saponins, tannins, bioflavonoids	Natural surfactant; pH stabilisation; cleansing

Reetha	*Sapindus mukorossi Gaertn.*	Sapindaceae	Pericarp	Triterpenoid saponins (mukorozisaponins)	Natural foaming and cleansing agent
Fenugreek	*Trigonella foenum-graecum L.*	Fabaceae	Seeds	Trigonelline, diosgenin, saponins, mucilage, proteins	Conditioning; antifungal (anti-dandruff)
Rice	*Oryza sativa L.*	Poaceae	Grains	Inositol, γ-oryzanol, phenolic acids, proteins, starch	Hair shaft structural support; shine; elasticity

Preparation of Plant Extracts

Individual aqueous extracts were prepared by classical decoction: 5 g of coarsely powdered plant material was soaked in 100 mL double-distilled water for 12 hours, and then boiled for 30 minutes. After cooling, the mixture was filtered through muslin cloth followed by Whatman No. 1 filter paper. The filtrate was concentrated at 50°C under reduced pressure and stored at 4°C in sealed amber glass containers. Extract yield (%) was calculated as:

Extract Yield (%) = (Weight of recovered extract ÷ Weight of starting crude drug) × 100

Preliminary Phytochemical Screening

Qualitative phytochemical analysis was conducted on each extract to detect: alkaloids (Dragendorff's reagent), flavonoids (Shinoda test), tannins ($FeCl_3$), saponins (foam test), glycosides (Keller-Killiani test), phenolics ($FeCl_3$), terpenoids (Salkowski's test), and proteins (Biuret test).[9,10] Results are presented in Table 2.

Table 2: Qualitative phytochemical screening results of the seven plant extracts.

Constituent	Test/Reagent	Hibiscus	Bhringraj	Amla	Shikakai	Reetha	Fenugreek	Rice
Alkaloids	Dragendorff's	−	+	−	−	−	+	−
Flavonoids	Shinoda test	+	+	+	+	−	+	+
Tannins	$FeCl_3$ solution	+	+	++	+	−	−	−
Saponins	Foam test	+	−	−	++	++	+	−
Glycosides	Keller–Killiani	−	+	+	+	+	+	−
Phenolics	$FeCl_3$ solution	+	+	++	+	−	+	+
Terpenoids	Salkowski's test	−	+	−	−	+	+	−
Proteins	Biuret test	+	−	−	+	−	++	++

(+) Present; (++) Present in high concentration; (−) Absent

Formulation Design and Preparation

Three formulations (F1, F2, F3) were developed with varied herbal extract concentrations (Table 3). SLS was incorporated at 15-16% w/v as co-surfactant; sodium benzoate at 0.5% w/v as antimicrobial preservative; and citric acid (10% w/v solution) for pH adjustment to 5.0-7.0. All herbal extracts were blended under magnetic stirring at 300 rpm. SLS was added

to the herbal mixture while being continuously stirred after being separately dissolved in warm distilled water. Following pH adjustment with citric acid, addition of perfume, and volume make-up with distilled water, each batch was homogenised for 10 minutes and transferred to sealed amber glass containers.[11,12]

Table 3: Formulation composition of polyherbal shampoo.

Ingredient	F1 (% v/v)	F2 (% v/v)	F3* (% v/v)	Functional Role
H. rosa-sinensis extract	5	6	5	Conditioning agent
E. alba extract	4	4	5	Follicular anagen stimulant
P. emblica extract	5	6	5	Antioxidant / pH buffering
A. concinna extract	8	7	9	Natural surfactant / pH stabilisation
S. mukorossi extract	8	9	8	Natural cleansing and foaming agent
T. foenum-graecum extract	3	3	4	Thickener / conditioner / antifungal
O. sativa extract	2	2	3	Hair shaft structural support
Sodium lauryl sulfate (SLS)	15	15	16	Synthetic co-surfactant
Sodium benzoate	0.5	0.5	0.5	Antimicrobial preservative
Perfume	0.2	0.2	0.2	Fragrance
Citric acid / Distilled water	q.s.	q.s.	q.s.	Vehicle / pH adjustment to 100 mL

Physicochemical Evaluation

Each formulation batch was evaluated in triplicate using the following standardised methods:

(a) Organoleptic assessment: The formulations were visually examined for appearance, colour, homogeneity, and consistency, while odour was assessed by sensory evaluation.

(b) pH measurement: The pH of each formulation was measured using a calibrated digital pH meter. Prior to analysis, the shampoo sample was diluted with an equal volume of distilled water.[13]

(c) Viscosity: The rheological behaviour of the formulations was determined using a Brookfield viscometer. Measurements were carried out at 25 ± 0.5°C employing spindle No. 4 at a rotational speed of 50 rpm. The viscosity values were expressed in centipoise.[14]

(d) Foam volume and stability: Foaming characteristics were assessed by transferring 1 mL of shampoo formulation into a graduated 100 mL cylinder followed by dilution with distilled water. The cylinder was shaken uniformly for 1 min to generate foam. The foam volume was measured immediately after shaking (T_0) and again after 5 min (T_5) to evaluate foam retention capacity.[15,16]

Foam Stability (%) = (Foam volume at T_5 / Foam volume at T_0) × 100

(e) Dirt dispersion: Two drops of shampoo were added to 10 mL of distilled water in a test tube and shaken to produce foam. One drop of India ink was then added, and the distribution of ink in the foam was observed. Lower ink concentration in the foam indicated better cleansing efficiency.[17]

(f) Surface tension: Surface tension was determined using the stalagmometric method. Measurements were calculated relative to distilled water, which served as the reference standard. The test was performed to evaluate the ability of the formulation to reduce interfacial tension and facilitate cleansing action.[18]

(g) Wetting time: Wetting efficiency was evaluated using a standard canvas disc method. A canvas disc measuring approximately 1 cm^2 was gently placed on the surface of the shampoo solution, and the time required for complete immersion was recorded in seconds.[19]

(h) Total solid content: 4 g sample was dried at 105°C to a constant weight; expressed as percentage of the original sample weight.[20]

RESULTS

Organoleptic and Physical Characteristics

All three formulations were clear, homogeneous, free-flowing liquids with no visible sedimentation or turbidity after homogenisation. Formulations F1 and F3 showed a dark to black colour attributed to the high tannin and phenolic content of *P. emblica* and *E. alba* at their respective concentrations; F2 appeared dark brown. F1 and F3 exhibited a pleasant botanical fragrance, while F2 showed a more pronounced herbaceous odour. These observations are consistent with previously reported multi-botanical shampoo systems.[11,12]

Physicochemical Evaluation

Complete physicochemical data are presented in Table 4. pH ranged from 5.9 to 6.2, within the skin-compatible target (5.0-7.0) and aligned with the scalp acidic mantle. Viscosity increased progressively: F1 (820 ± 15 cps) < F2 (860 ± 10 cps) < F3 (920 ± 12 cps), all within the commercial standard (800-1000 cps). F3 exhibited the highest foam volume (120 ± 3 mL) and foam stability (90.8%), with excellent dirt dispersion, lowest surface tension (31.8 ± 0.5 dyne/cm), most rapid wetting time (41 ± 1.5 s), and optimal total solid content (24 ± 0.5%).[9,11,13]

Table 4: Physicochemical evaluation of formulations F1, F2, and F3 with standard benchmarks.

Parameter	F1	F2	F3 (Optimal)*	Standard Range
Appearance	Black, clear, homogeneous	Dark brown, clear	Black, clear, homogeneous	Clear, homogeneous liquid
Odour	Pleasant botanical	Herbaceous	Pleasant botanical	Characteristic
pH	6.1 ± 0.1	6.2 ± 0.1	5.9 ± 0.1	5.0-7.0
Viscosity (cps)	820 ± 15	860 ± 10	920 ± 12	800-1000
Foam volume (mL)	95 ± 4	105 ± 3	120 ± 3	> 60
Foam stability (%)	82.1	85.6	90.8	> 70
Dirt dispersion	Good	Good	Excellent	Good-Excellent
Surface tension (dyne/cm)	34.2 ± 0.8	33.5 ± 0.6	31.8 ± 0.5	< 40
Wetting time (s)	52 ± 2	47 ± 2	41 ± 1.5	< 60
Total solids (%)	22 ± 0.5	23 ± 0.4	24 ± 0.5	18-25

*F3 = Optimised batch; cps = centipoise; dyne/cm = dynes per centimetre; n = 3; values as mean ± SD

Benchmarking Against Commercial Products

Compared with marketed synthetic and semi-herbal shampoos, F3 demonstrated competitive pH, viscosity, and foam performance.[21,13] The incorporation of seven botanicals at therapeutically significant concentrations versus the trace herbal quantities typical of commercial semi-herbal brands suggests substantially lower potential for scalp irritation and a superior functional phytochemical profile.

DISCUSSION

The present investigation aimed to develop and evaluate a polyherbal shampoo incorporating seven traditionally recognized medicinal plants with established benefits for hair and scalp care. The physicochemical assessment revealed that all formulations possessed acceptable quality attributes; however, formulation F3 consistently demonstrated superior performance across the evaluated parameters, indicating that the selected ratio of herbal extracts and excipients provided the most balanced formulation. The observed results suggest that the synergistic interaction among the botanical constituents contributed significantly to the cleansing, conditioning, and stability characteristics of the shampoo.[24,25]

pH and Scalp Suitability

An appropriate pH is essential for maintaining scalp health and preserving the structural integrity of the hair shaft. The formulations exhibited pH values ranging from 5.9 to 6.2, which are close to the natural pH of healthy scalp skin. Such mildly acidic conditions help maintain cuticular compactness, reduce hair fibre swelling, and minimize scalp irritation. The pH profile obtained in the present study may be attributed to the presence of naturally occurring acidic phytoconstituents, particularly phenolic acids and vitamin C derivatives present in Phyllanthus emblica, together with flavonoid-rich compounds found in Acacia concinna. The results indicate that the herbal ingredients themselves contributed to maintaining pH balance, thereby reducing dependence on synthetic pH-adjusting agents.

Foaming Characteristics and Cleansing Performance

Foam generation and retention are important quality indicators for shampoo formulations because consumers often associate rich and stable foam with effective cleansing. The increase in foam volume and foam stability observed from F1 to F3 indicates improved surfactant activity in the optimized formulation.[15,16] This enhancement can be explained by the presence of natural saponins derived from Sapindus mukorossi and Acacia concinna. These molecules possess both hydrophilic and hydrophobic regions, enabling efficient reduction of interfacial tension and stabilization of air bubbles within the foam structure. The combined action of these natural surfactants with sodium lauryl sulfate likely produced a synergistic effect, resulting in improved foaming performance and cleansing efficiency.[7]

Rheological Properties and Product Acceptability

Viscosity is a critical parameter influencing the ease of application, spreadability, and overall consumer acceptability of shampoo products. The viscosity values obtained for the formulations were within the range commonly considered suitable for commercial liquid shampoos.[14] Formulation F3 exhibited the highest viscosity, which may be attributed to the thickening effect of polysaccharides present in Hibiscus rosa-sinensis and the mucilage-rich components of Trigonella foenum-graecum. These naturally occurring biopolymers contribute to desirable flow behaviour while avoiding the need for excessive synthetic viscosity modifiers. The observed rheological characteristics suggest that the formulation would provide convenient handling and uniform distribution during application.[26]

Surface Tension and Wetting Ability

Effective shampoos must possess the ability to rapidly wet and spread across hair fibres and scalp surfaces. The gradual reduction in surface tension observed from F1 to F3 reflects improved surfactant efficiency and enhanced cleansing potential.[18] A lower surface tension facilitates penetration of the formulation into the spaces between hair strands, thereby promoting efficient removal of accumulated dirt, oil, and debris. This observation was further supported by the reduction in wetting time, indicating improved spreading characteristics and greater contact between the cleansing agents and the hair surface. The findings demonstrate that the optimized formulation possesses favourable physicochemical properties for effective cleansing action.[19]

Functional Role of the Herbal Ingredients

The effectiveness of the developed shampoo can be attributed to the complementary biological activities of the incorporated medicinal plants. Eclipta alba has traditionally been recognized for promoting healthy hair growth and supporting follicular function through its diverse phytoconstituent profile. Phyllanthus emblica serves as a rich source of antioxidant compounds capable of protecting scalp tissues and hair follicles against oxidative damage.[4]

The inclusion of Trigonella foenum-graecum may contribute to scalp nourishment and microbial balance due to its phenolic and alkaloidal constituents. Hibiscus rosa-sinensis provides conditioning and moisturizing benefits through its mucilage content, while Sapindus mukorossi and Acacia concinna function as natural cleansing agents owing to their high saponin content.[7,27]

A distinctive feature of the formulation is the incorporation of Oryza sativa extract. Rice-derived bioactive compounds, including inositol and γ-oryzanol, have been associated with protection of hair fibres and improvement of hair strength.[28] These constituents may help maintain hair integrity by supporting the structural stability of damaged regions of the hair shaft and providing antioxidant protection against environmental stressors.

Significance of the Optimized Formulation

Among the tested formulations, F3 exhibited the most desirable combination of physicochemical properties, including suitable pH, enhanced foaming ability, greater foam stability, optimal viscosity, reduced surface tension, and improved wetting characteristics. These results suggest that the formulation possesses the necessary attributes for efficient

cleansing while maintaining scalp compatibility and hair conditioning effects. The findings further highlight the potential of combining traditional Ayurvedic botanicals with modern formulation strategies to produce effective and consumer-acceptable herbal cosmetic products.[11,12]

Overall Assessment

The study demonstrates that a carefully designed polyherbal shampoo can achieve physicochemical characteristics comparable to those expected of commercial hair cleansing preparations while utilizing predominantly plant-based ingredients.[21,23] The optimized formulation offers a multifunctional approach by integrating cleansing, conditioning, antioxidant protection, and scalp-supportive properties within a single preparation. These outcomes support the potential application of the developed herbal shampoo as a safe and effective alternative to conventional synthetic formulations and provide a foundation for future biological and clinical evaluation.

CONCLUSION

A biodegradable liquid polyherbal shampoo incorporating aqueous extracts of seven traditional Ayurvedic botanicals - *H. rosa-sinensis, E. alba, P. emblica, A. concinna, S. mukorossi, T. foenum-graecum*, and *O. sativa* was successfully formulated, optimised, and physicochemically evaluated. Among the three batches, formulation F3 demonstrated superior performance across all evaluated parameters. The synergistic phytochemical profile of the seven-herb system comprising wedelolactone and eclalbatin (*E. alba*), triterpenoid saponins (*S. mukorossi*, *A. concinna*), ascorbic acid and tannins (*P. emblica*), and inositol and γ-oryzanol (*O. sativa*) confers multifunctional benefits within a single biodegradable, biocompatible preparation.

Future studies should encompass: (i) long-term accelerated stability testing under ICH Q1A conditions; (ii) randomised controlled clinical efficacy trials for hair growth density, tensile strength, and scalp health; (iii) dermatological safety evaluation (Draize patch test, HRIPT); (iv) *in-vitro* antifungal activity testing against *Malassezia globosa* and *M. restricta*; and (v) consumer acceptability surveys for regulatory submission.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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