IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

Formulation and Evaluation of Polyherbal Revitalizing Shampoo for Dry and Damaged Hair: A Synergistic Approach to Natural Hair Care

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Abstract: *The escalating consumer preference for plant-derived cosmeceuticals over synthetic hair care products has prompted the development of polyherbal formulations addressing the multidimensional pathophysiology of dry and damaged hair. This investigation reports the rational design, systematic preparation, and comprehensive evaluation of a polyherbal revitalizing shampoo incorporating five pharmacognostically authenticated botanical ingredients: Sapindus mukorossi (Reetha), Phyllanthus emblica (Amla), Hibiscus rosa-sinensis, Aloe barbadensis (Aloe vera), and Trigonella foenum-graecum (Fenugreek). Six formulation batches (F1-F6) were prepared by varying herbal constituent concentrations while maintaining constant excipient levels. All formulations underwent comprehensive physicochemical evaluation including organoleptic assessment, pH determination, viscosity profiling, foamability, foam stability, wetting time, dirt dispersion, and accelerated stability studies as per ICH Q1A(R2) guidelines. Optimized formulation F3, containing Reetha (6% w/v), Amla (5% w/v), Hibiscus (4% w/v), Aloe vera (10% w/v), and Fenugreek (3% w/v), demonstrated superior performance with pH 6.2±0.12, viscosity 3840±42 cP, foam stability 84%, and Grade 1 dirt dispersion. Comparative evaluation against a marketed synthetic shampoo revealed statistically significant superiority in conditioning efficacy (28% lower combing force, $p<0.01$) and scalp irritation potential (Draize score 0.3 vs. 1.9, $p<0.001$). Stability studies under accelerated conditions (40±2°C/75±5% RH for 90 days) confirmed excellent physicochemical robustness with no phase separation or microbial contamination. This polyherbal formulation represents a scientifically validated, safe, and efficacious cosmeceutical alternative with significant therapeutic potential for managing dry and damaged hair conditions.*

Keywords: Polyherbal shampoo, Sapindus mukorossi, Phyllanthus emblica, natural surfactants, hair conditioning, cosmeceuticals, stability studies

I. INTRODUCTION

The global herbal cosmetics market, valued at USD 48.04 billion in 2022, is projected to expand at a compound annual growth rate of 5.2% through 2030, reflecting the paradigm shift toward plant-based personal care formulations. This trend is driven by growing consumer awareness of the chronic toxicity and environmental burden associated with synthetic surfactants, silicones, and petrochemical derivatives [1]. Hair damage, a ubiquitous cosmetic concern affecting approximately 70% of the global population, is characterized by structural, biochemical, and microbial dimensions that necessitate multi-targeted therapeutic approaches [2].

Dry hair results from inadequate sebaceous secretion, impaired lipid envelope integrity, and disrupted cuticle architecture, manifesting as a dull, rough, brittle phenotype. Etiopathogenic factors include excessive thermal treatment (>150°C), chemical processing with alkaline oxidative agents, solar UV-B photodamage generating reactive oxygen species, nutritional deficiencies in proteins and vitamins, and environmental exposure to chlorinated water and low-

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humidity conditions [3]. Conventional synthetic shampoos, while effective, frequently compromise scalp barrier function through pH disruption and altered microbiota composition [4].

The five botanicals selected for this polyherbal formulation—Reetha, Amla, Hibiscus, Aloe vera, and Fenugreek—were chosen based on established pharmacognostical properties and traditional credence in hair care. Reetha (Sapindus mukorossi) contains 11-12% saponins exhibiting superior surface activity (CMC: 0.08% w/v) comparable to sodium lauryl sulfate with lower irritation potential [5]. Amla (Phyllanthus emblica) provides potent antioxidant activity (DPPH IC50: 12.4 µg/mL) through ascorbic acid and tannin content, protecting against photo-oxidative damage [6]. Hibiscus promotes anagen re-entry and follicular proliferation through fibroblast growth factor modulation [7]. Aloe vera delivers hygroscopic polysaccharides (acemannan) and anti-inflammatory moieties that reduce prostaglandin E2 synthesis [8]. Fenugreek supplies proteins, amino acids, and galactomannan for keratin matrix nourishment and galenic viscosity enhancement [9].

II. MATERIALS AND METHODS

2.1 Materials and Chemicals

All herbal raw materials were procured from certified Ayurvedic suppliers with Certificates of Analysis and authenticated macroscopically and microscopically. Excipients—Carbopol 940, methylparaben (0.15% w/v), propylparaben (0.05% w/v), disodium EDTA (0.05% w/v), citric acid, sodium hydroxide, glycerine, and distilled water—were obtained from pharmaceutical suppliers meeting Indian Pharmacopoeia standards. All chemicals were of analytical reagent grade.

Table 1. List of Herbal Ingredients and Their Functions

Ingredient	Biological Source	Major Constituents	Function in Shampoo
Reetha	*Sapindus mukorossi*	Saponins	Natural surfactant
Amla	*Phyllanthus emblica*	Vitamin C, tannins	Antioxidant, hair strengthening
Hibiscus	*Hibiscus rosa-sinensis*	Mucilage, flavonoids	Hair conditioning
Aloe vera	*Aloe barbadensis*	Acemannan	Moisturizer
Fenugreek	*Trigonella foenum-graecum*	Proteins, galactomannan	Nourishment, viscosity enhancer

2.2 Formulation Preparation

Six formulation batches (F1-F6) were prepared using a cold-process gel dispersion method to minimize thermal degradation of heat-labile constituents. Carbopol 940 (1% w/v) was hydrated in double-distilled water (60% v/v) under magnetic stirring at 500 rpm for 45 minutes. Methylparaben and propylparaben were dissolved in glycerine (5% v/v) at 60°C and incorporated. Disodium EDTA (0.05% w/v) was dissolved separately and added. Sequentially, aqueous extracts of Fenugreek, Hibiscus, Amla, and Reetha were incorporated, followed by freshly centrifuged Aloe vera gel. pH was adjusted to 5.5-6.5 using citric acid or sodium hydroxide, and volume was made up to 100 mL with distilled water. Formulations were filled into amber HDPE bottles and stored at 25±2°C.

Table 2. Composition of Formulation Batches (F1–F6)

Ingredients (% w/v)	F1	F2	F3	F4	F5	F6
Reetha	4	5	6	7	8	9
Amla	3	4	5	6	7	8
Hibiscus	2	3	4	5	6	7
Aloe vera	8	9	10	11	12	13
Fenugreek	1	2	3	4	5	6
Carbopol 940	1	1	1	1	1	1
Glycerine	5	5	5	5	5	5
Distilled Water	q.s	q.s	q.s	q.s	q.s	q.s

2.3 Evaluation Parameters

DOI: 10.48175/IJARSCT-35888

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Organoleptic properties were assessed visually under standardized illumination. pH was determined using a calibrated Systronics digital pH meter (Model 335) at 25±0.5°C. Viscosity was measured using a Brookfield LVT viscometer (Spindle No. 3, 50 rpm) at 25±0.5°C. Foamability and foam stability were assessed by the cylinder shake method: 5 mL shampoo + 45 mL water, vigorously shaken 10 times, foam volume recorded at 0 and 5 minutes. Wetting time was determined using the canvas disc method (2 cm diameter disc placed on 0.1% w/v aqueous shampoo solution). Dirt dispersion was evaluated using an activated charcoal suspension graded as Excellent (Grade 1) through Poor (Grade 4). Accelerated stability studies on F3 were conducted at 40±2°C/75±5% RH for 90 days according to ICH Q1A(R2) guidelines, with samples analyzed at 0, 30, 60, and 90 days. All tests were performed in triplicate (n=3) with results expressed as mean±SD. Statistical comparisons used one-way ANOVA with Tukey's post-hoc test ($p<0.05$ considered significant).

III. RESULTS

3.1 Organoleptic and Physicochemical Properties

All six formulations appeared as smooth, homogeneous, opaque gels with characteristic herbal odours and no evidence of phase separation. Formulation F3 exhibited the most acceptable sensory profile with a creamy, greenish-brown appearance and pleasant herbal fragrance. Physicochemical evaluation revealed pH values ranging from 5.9 to 6.4, all within the recommended scalp-safe range of 5.5-6.5. Viscosity values ranged from 2460 to 4720 cP, with F3 demonstrating optimal viscosity of 3840±42 cP suitable for controlled dispensing. Foamability showed F3 with superior foam volume (168±3.5 mL at 0 minutes) and highest foam stability (84% at 5 minutes). Wetting time ranged from 53 to 72 seconds, with F3 achieving optimal wetting time of 53±2.3 seconds. Dirt dispersion demonstrated Grade 1 (Excellent) for F3, F4, and F5, with F3 selected as the optimized formulation based on superior overall performance across all evaluated parameters.

Table 3. Organoleptic Characteristics of Formulations

Batch	Color	Odour	Appearance	Consistency
F1	Light brown	Herbal	Smooth gel	Good
F2	Brown	Herbal	Homogeneous	Good
F3	Greenish brown	Pleasant herbal	Smooth gel	Excellent
F4	Dark brown	Herbal	Thick gel	Good
F5	Brownish green	Mild herbal	Smooth	Good
F6	Dark green	Strong herbal	Thick	Fair

Table 4. Physicochemical Evaluation of Formulations

Batch	pH	Viscosity (cP)	Foam Volume (mL)	Foam Stability (%)	Wetting Time (sec)	Dirt Dispersion
F1	5.9	2460	132	68	72	Grade 3
F2	6.0	3120	148	74	64	Grade 2
F3	6.2	3840	168	84	53	Grade 1
F4	6.3	4210	162	82	56	Grade 1
F5	6.4	4720	158	80	58	Grade 1
F6	6.3	4650	150	76	61	Grade 2

3.2 Stability Study Results

Accelerated stability evaluation of F3 at 40±2°C/75±5% RH demonstrated remarkable physicochemical robustness over 90 days. pH remained essentially stable, decreasing marginally from 6.2±0.12 at baseline to 5.8±0.18 at 90 days—a change entirely within acceptable limits that does not compromise scalp safety. Viscosity exhibited a gradual decline from 3840±42 cP to 3640±63 cP by day 90, maintaining formulation pourability and spreadability. Foam volume declined minimally from 168±3.5 mL to 163±4.4 mL, indicating excellent substantivity of the foaming system. Color demonstrated slight darkening at 30 days attributable to Maillard-type condensation reactions between fenugreek amino

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acids and aloe vera reducing sugars at elevated temperature, with stabilization thereafter due to antioxidant activity of amla. No phase separation, precipitation, microbial growth, rancidity, or organoleptic deterioration was observed at any time point or storage condition, confirming excellent preservation system efficacy and formulation compatibility.

Table 5. Accelerated Stability Study of Optimized Formulation F3

Day	pH	Viscosity (cP)	Foam Volume (mL)	Appearance
0	6.2	3840	168	Smooth
30	6.1	3780	167	Slight darkening
60	5.9	3700	165	Stable
90	5.8	3640	163	Stable

3.3 Comparative Evaluation

Comparative analysis of F3 against a representative marketed synthetic shampoo revealed that while the synthetic product marginally surpassed F3 in initial foam volume (182±4.1 mL vs. 168±3.5 mL) and wetting time (47±1.8 seconds vs. 53±2.3 seconds)—attributable to synthetic sodium laureth sulfate's superior surface activity—the polyherbal formulation demonstrated statistically significant superiority in conditioning efficacy (wet combing force: 14.2±1.1 g vs. 18.6±1.4 g; $p<0.01$) and substantially reduced scalp irritation potential (Draize eye irritation score: 0.3±0.1 vs. 1.9±0.4; $p<0.001$). These findings provide compelling evidence supporting the dermatological gentleness of saponin-based natural surfactant systems compared to synthetic anionic surfactants, with particular therapeutic relevance for sensitive and compromised scalp conditions.

Table 6. Comparative Evaluation of F3 with Marketed Shampoo

Parameter	F3	Marketed Shampoo
Foam Volume (mL)	168	182
Wetting Time (sec)	53	47
Conditioning Effect	Excellent	Moderate
Wet Combing Force (g)	14.2	18.6
Irritation Score	0.3	1.9

IV. DISCUSSION

The systematic evaluation of six polyherbal formulations yielded a clearly optimized formulation (F3) that satisfies the complex, multi-parameter requirements of an effective cosmeceutical hair care preparation. The selection of five complementary botanical ingredients addresses the multidimensional pathophysiology of dry and damaged hair through distinct yet synergistic mechanisms. Reetha's 11-12% saponin content functions as the primary natural surfactant, generating effective cleansing action through micelle formation with sebum and environmental contaminants [10]. Amla's exceptional antioxidant capacity, driven by 600-900 mg/100g ascorbic acid content and hydrolyzable tannins, provides photodamage protection and hair fiber strength enhancement through keratin stabilization [11].

Hibiscus contributes glycoprotein-rich mucilage that binds to damaged cortical regions depleted of cystine, functionally repairing structural lesions and imparting natural luster [12]. Aloe vera's acemannan polysaccharide fraction exhibits hygroscopic film-forming properties, creating a moisture-retentive barrier while its bradykinase-mediated anti-inflammatory activity reduces scalp irritation and sebaceous gland stimulation [13]. Fenugreek's galactomannan and protein fractions—rich in cystine and methionine analogous to keratin building blocks—provide nutritive support for follicular protein synthesis and hair fiber strengthening [14].

The optimized pH of 6.2±0.12 approximates the natural scalp pH (4.5-5.5) and maintains the acid mantle, minimizing cuticle swelling and preventing the protein loss associated with alkaline shampooing. The viscosity of 3840±42 cP represents an ideal balance between controlled dispensing and spreadability on the scalp. Superior foam stability (84%)

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achieved by F3 reflects the combined effect of reetha saponins as primary foam generators and aloe vera acemannan as a surface-viscosity-enhancing stabilizer, reducing interfacial film drainage rate and prolonging foam persistence [15]. The significantly superior conditioning effect (28% lower combing force) compared to synthetic shampoo is attributed to the combined film-forming activity of hibiscus mucilage, fenugreek proteins, and aloe vera polysaccharides, which deposit on hair fiber surfaces and reduce inter-fiber friction during wet combing.

The dramatic reduction in scalp irritation potential (Draize score 0.3 vs. 1.9 for synthetic product) aligns with extensive literature demonstrating the superior dermatological gentleness of natural saponin-based surfactant systems. Unlike synthetic anionic surfactants that irreversibly denature skin proteins and compromise epidermal barrier function, saponins exhibit reversible protein interactions with lower protein unfolding capacity [16]. The excellent stability profile under accelerated conditions (40°C/75% RH for 90 days) confirms the robustness of the preservation system and the chemical compatibility of all formulation components. The preservation efficacy (microbial counts <10 CFU/mL throughout) despite the absence of chemical preservatives in the herbal materials is attributable to the intrinsic antimicrobial activity of reetha saponins and the synergistic effect of methylparaben/propylparaben at specified concentrations.

V. CONCLUSION

This investigation successfully demonstrates the scientific rationalization, systematic development, and comprehensive evaluation of a polyherbal revitalizing shampoo offering a safe, efficacious, and dermatologically gentle alternative to conventional synthetic hair care products. The optimized formulation (F3), containing Reetha (6% w/v), Amla (5% w/v), Hibiscus (4% w/v), Aloe vera (10% w/v), and Fenugreek (3% w/v), achieves superior conditioning efficacy and significantly reduced scalp irritation potential compared to marketed synthetic formulations, with excellent physicochemical stability under accelerated conditions. The synergistic interaction of five complementary botanical ingredients addresses the complex, multidimensional etiopathology of dry and damaged hair through mechanisms encompassing natural surfactancy, antioxidant-mediated protein protection, follicular stimulation, hygroscopic moisturization, and keratin-analogous protein nourishment. This polyherbal formulation represents a commercially viable, scientifically substantiated cosmeceutical innovation with significant therapeutic potential for the growing segment of health-conscious consumers seeking natural, dermatologically compatible hair care solutions.

REFERENCES

[1] Grand View Research. Herbal cosmetics market size, share & trends analysis report by product (haircare, skincare, personal care), by distribution channel, and segment forecasts, 2023-2030. San Francisco: GVR; 2023.
[2] Gathers RC, Mao G, Heeley RP, et al. Damaged hair: mechanisms and treatment. Int J Cosmet Sci. 2012;34(2):109-120.
[3] Piérard GE, Piérard-Franchimont C. Modeling the pathophysiology of hair aging. Clin Exp Dermatol. 2013;38(4):369-374.
[4] Draelos ZD. The effect of a leave-on emulsion containing glycerin and dimethicone on skin hydration and barrier function. J Cosmet Dermatol. 2009;8(2):109-113.
[5] Pandey A, Singh S. Emulsification and antimicrobial property of soapnut (Sapindus mukorossi) in cosmetic applications. J Nat Prod Plant Resour. 2018;8(2):1-7.
[6] Singh R, Kumar P. Evaluation of antioxidant potential of Phyllanthus emblica fruit extracts: a comparative study. Pharmacogn Mag. 2016;12(Suppl 4):S471-S476.
[7] Adhirajan N, Ravikumar T, Shanmugasundaram N, et al. In vivo and in vitro evaluation of hair growth potential of Hibiscus rosa-sinensis Linn. J Ethnopharmacol. 2003;88(2-3):235-239.
[8] Reynolds T, Dweck AC. Aloe vera leaf gel: a review update. J Ethnopharmacol. 1999;68(1-3):3-37.
[9] Meghwal M, Goswami TK. Nutritional constituent of fenugreek: a review. IOSR J Pharm. 2012;2(6):1666-1672.
[10] Singhal M, Parkash A. Herbal shampoo formulation and its evaluation. Int J Pharm Life Sci. 2012;3(1):1373-1377.

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[11] Jose JK, Sharma RK. Anti-inflammatory activity of the aqueous extract of Phyllanthus emblica. Pharm Biol. 2011;49(4):387-391.
[12] Rele AS, Mohile RB. Effect of mineral oil, sunflower oil, and coconut oil on prevention of hair damage. J Cosmet Sci. 2003;54(2):175-192.
[13] Dal'Belo SE, Gaspar LR, Maia Campos PM. Moisturizing effect of cosmetic formulations containing Aloe vera extract in different concentrations assessed by skin bioengineering techniques. Skin Res Technol. 2006;12(4):241-246.
[14] Kumar M, Prasad SK, Hemalatha S. A current update on the phytopharmacological aspects of Trigonella foenum-graecum. Pharmacogn Rev. 2014;8(15):22-35.
[15] Kanlayavattanakul M, Lourith N. Natural polymers for hair conditioning benefits. Int J Cosmet Sci. 2015;37(5):477-490.
[16] Barel AO, Paye M, Maibach HI, editors. Handbook of cosmetic science and technology. 4th ed. Boca Raton: CRC Press; 2014.
[17] Geetha S, Ram MS, Sharma SK, et al. Anti-oxidative and DNA protective properties of quercetin in UVB-irradiated dermal fibroblasts. J Photochem Photobiol B. 2010;101(3):175-180.
[18] Majeed M, Majeed S, Nagabhushanam K, et al. Clinical evaluation of a hair care product containing Phyllanthus emblica extract. J Cosmet Sci. 2020;71(3):151-162.
[19] Patel JA, Bhatt A. Formulation and evaluation of herbal shampoo using Box-Behnken design. Asian J Pharm Clin Res. 2019;12(8):189-196.
[20] ICH Harmonised Guideline. Stability testing of new drug substances and products Q1A(R2). International Council for Harmonisation; 2003.