



Research Article

Formulation and Evaluation of Polyherbal Hair Oil Containing Nagarmotha, Curry Leaves, Amla, Hibiscus, Fenugreek, and Coconut Oil

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Background: Herbal hair oils represent an important segment of cosmeceutical preparations with immense therapeutic and nutritive potential. The present study aims to develop and evaluate a polyherbal hair oil incorporating five medicinally significant plant extracts Nagarmotha (*Cyperus rotundus*), Curry Leaves (*Murraya koenigii*), Amla (*Phyllanthus emblica*), Hibiscus (*Hibiscus rosa-sinensis*), and Fenugreek (*Trigonella foenum-graecum*) in a coconut oil base. **Methods:** Three formulations (F1, F2, F3) were prepared with varying concentrations of herbal extracts. The formulations were subjected to organoleptic evaluation (colour, odour, taste), physicochemical parameters (pH, viscosity, specific gravity, refractive index, acid value, peroxide value), and accelerated stability testing at 25°C, 40°C, and 45°C for six months. **Results:** All three formulations demonstrated acceptable physicochemical profiles. F2 showed the optimum balance between extract concentration and physicochemical stability, with pH 5.5 ± 0.04 , viscosity 48.7 ± 1.5 mPa·s, and no significant changes during the stability period. **Conclusion:** The polyherbal formulation F2 is stable, cosmetically elegant, and shows promising potential for hair growth promotion and scalp health maintenance.

Keywords: Polyherbal hair oil, Nagarmotha, Curry leaves, Amla, Hibiscus, Fenugreek, Physicochemical evaluation, Stability analysis, Cosmeceutical.

INTRODUCTION

Hair care represents one of the most ancient traditions in human grooming and therapeutics. Across Asia, particularly in the Indian subcontinent, the application of herbal oils to the scalp has been practiced for millennia, with Ayurvedic texts such as the Charaka Samhita and Sushruta Samhita extensively documenting the formulation and use of medicated oils (taila kalpana) for promoting hair growth, preventing premature greying, and maintaining scalp health [1, 2]. Hair loss (alopecia) and scalp disorders including dandruff (seborrheic dermatitis), scalp dryness, and follicular inflammation represent significant dermatological concerns globally. Studies indicate that androgenetic alopecia affects approximately 50% of men by age 50 and nearly 25% of women by age 60, whereas telogen effluvium and

nutritional deficiency-related hair loss are increasingly prevalent due to modern lifestyle changes [3]. Despite the availability of synthetic pharmacological agents such as minoxidil and finasteride, these treatments are associated with systemic side effects, cost burdens, and limited long-term efficacy, driving renewed interest in plant-derived therapeutic alternatives [4]. Plant derived cosmeceuticals offer multifaceted bioactivities including antioxidant, anti-inflammatory, antimicrobial, and 5 α -reductase inhibitory properties, which collectively address the pathophysiology of hair loss and scalp disorders without significant adverse effects [5]. The formulation of polyherbal hair oils enables synergistic interactions between phytoconstituents, potentially producing enhanced therapeutic outcomes compared to single herb preparations [6]. The herbs selected in the present

study Nagarmotha (*Cyperus rotundus* Linn.), Curry Leaves (*Murraya koenigii* Spreng.), Amla (*Phyllanthus emblica* Linn.), Hibiscus (*Hibiscus rosa-sinensis* Linn.), and Fenugreek (*Trigonella foenum-graecum* Linn.) have individually demonstrated pharmacological activities relevant to hair care, including antifungal, hair growth promoting, antioxidant, and anti-inflammatory properties, as substantiated by a growing body of *in vitro*, *ex vivo*, and clinical studies [7–12]. Coconut oil (*Cocos nucifera*) was selected as the base owing to its excellent penetration into the hair shaft, its capacity to reduce protein loss from hair, and its widespread traditional use in Indian hair care [13]. The objectives of the present study were to: (i) Prepare three polyherbal hair oil formulations (F1, F2, F3) with varying extract concentrations (ii) Evaluate the formulations for organoleptic and physicochemical parameters (iii) Assess the accelerated stability of the formulations over a six-month period in accordance with International Council for Harmonisation (ICH) guidelines Q1A(R2).

MATERIALS AND METHODS

Plant Material Collection

Fresh plant material comprising rhizomes of *Cyperus rotundus*, leaves of *Murraya koenigii*, fresh fruits of *Phyllanthus emblica*, fresh flowers and leaves of *Hibiscus rosa-sinensis*, and seeds of *Trigonella foenum-graecum* were procured from a certified botanical garden and authenticated by a qualified pharmacognosist. Virgin coconut oil (cold-pressed) meeting the specifications of the Indian

Pharmacopoeia 2022 was obtained from a certified pharmaceutical grade supplier. All solvents and reagents used were of analytical reagent (AR) grade.

Preparation of Herbal Extracts

Each plant material was shade-dried at ambient temperature (25–30°C), coarsely powdered (sieve No. 40), and subjected to hot continuous extraction using a Soxhlet apparatus with 70% ethanol as the solvent. Extraction was continued for 18–24 cycles. The resultant extracts were filtered, concentrated under reduced pressure using a rotary evaporator at 45°C, and dried to yield semi-solid extracts. The yield (% w/w) was calculated on a dry weight basis. Extracts were stored at 4°C in amber colored glass containers until use [14].

Formulation of Polyherbal Hair Oil

Three formulations F1, F2, and F3 were prepared by dissolving weighed quantities of each herbal extract in a minimum volume of propylene glycol (acting as a co-solvent and humectant), followed by gradual incorporation into the pre heated (60°C) coconut oil base under continuous stirring using an overhead mechanical stirrer (500 rpm, 30 min). Vitamin E (tocopherol), BHT, and rosemary essential oil were added during the cooling phase (below 40°C) to prevent thermal degradation of the antioxidants. The formulations were stirred until homogeneous and allowed to cool to room temperature. The exact composition of each formulation is detailed in Table 1.

Table 1: Formulation composition of polyherbal hair oil (F1, F2, F3) per 100 g batch

Ingredient	F1 (% w/w)	F2 (% w/w)	F3 (% w/w)	Role / Purpose
Coconut Oil (base)	70	60	55	Base/carrier oil, emollient
Nagarmotha (<i>Cyperus rotundus</i>) Extract	5	8	10	Anti-dandruff, antimicrobial
Curry Leaves (<i>Murraya koenigii</i>) Extract	5	8	10	Hair growth stimulant, antioxidant
Amla (<i>Phyllanthus emblica</i>) Extract	8	10	12	Vitamin C source, hair strengthener
Hibiscus (<i>Hibiscus rosa-sinensis</i>) Extract	5	7	8	Scalp conditioner, promotes growth
Fenugreek (<i>Trigonella foenum-graecum</i>) Extract	5	5	3	Protein-rich, prevents hair fall
Vitamin E (Tocopherol)	1	1	1	Antioxidant preservative

Rosemary Essential Oil	0.5	0.5	0.5	Fragrance, antimicrobial
BHT (Butylated Hydroxy toluene)	0.1	0.1	0.1	Antioxidant stabilizer

Evaluation Parameters

Organoleptic Evaluation

Colour: The colour of each formulation was assessed visually under diffused natural light and recorded against a white background by three independent observers. Results were expressed descriptively.

Odour: The odour of each formulation was evaluated by trained panel members (n=5) under standardized conditions and scored on a 5 point hedonic scale: 1 (very unpleasant) to 5 (very pleasant). Mean scores $\pm$ SEM were recorded [15].

Taste: Although hair oils are for external use, taste evaluation was conducted for completeness as per regulatory guidelines for cosmeceuticals products, noting any bitterness imparted by the phytoconstituents. A small quantity (~0.1 mL) was placed on the tip of the tongue by trained panellists, and taste was recorded descriptively.

pH Determination

The pH of each formulation was determined using a calibrated digital pH meter (Systronics Model μ pH System 362, India) at $25 \pm 0.5^\circ\text{C}$. A 10% v/v dispersion of the oil in distilled water was prepared with the aid of Tween 80 (2%), vortexed for 2 min, and the pH was measured in triplicate. The pH meter was calibrated using standard buffer solutions (pH 4.0 and 7.0) prior to each measurement [16].

Viscosity Measurement

Apparent viscosity was determined using a Brookfield DV-E rotational viscometer equipped with spindle No. 64 at $25 \pm 0.5^\circ\text{C}$. Measurements were performed at 60 rpm in triplicate, and results were expressed in millipascal-seconds (mPa·s). Temperature was maintained using a circulating water bath. All readings were taken after 1 minute of equilibration at the set spindle speed [17].

Specific Gravity

Specific gravity was determined using a 25 mL pycnometer. The pycnometer was first weighed empty (W1), then filled with distilled water (W2), and finally filled with the sample (W3). Specific gravity was calculated using the formula: $\text{SG} = (\text{W3} - \text{W1}) / (\text{W2} - \text{W1})$. Measurements were conducted at 25°C in triplicate [18].

Refractive Index

The refractive index was determined at 25°C using an Abbe refractometer (ERMA Inc., Japan). A small drop of oil was placed on the prism surface, and the reading was taken in triplicate after temperature equilibration. The instrument was calibrated with distilled water (RI = 1.333 at 25°C) prior to measurements [18].

Acid Value

Acid value was determined as per the method described in the Indian Pharmacopoeia 2022 (IP 2022). Approximately 5 g of oil was dissolved in 50 mL of a neutralized ethanol-diethyl ether (1:1 v/v) mixture. The solution was titrated with 0.1 N KOH using phenolphthalein as the indicator. Acid value was calculated as: $\text{AV} = (56.1 \times V \times N) / W$, where V = volume of KOH consumed (mL), N = normality of KOH, and W = weight of sample (g) [19].

Peroxide Value

Peroxide value was determined by the iodometric method. Approximately 5 g of oil was dissolved in 30 mL of acetic acid–chloroform (3:2 v/v) solution and treated with 0.5 mL of saturated potassium iodide solution. After standing in the dark for exactly 1 minute, 30 mL of distilled water and starch indicator were added. Liberated iodine was titrated with 0.01 N sodium thiosulphate. Peroxide value was expressed in milliequivalents of active oxygen per kilogram of oil (meq/kg) [19, 20].

Accelerated Stability Testing

Stability studies were conducted in accordance with ICH Q1A(R2) guidelines. Samples were stored in

sealed amber glass bottles and placed in stability chambers set at three conditions: (i) 25°C/60% RH (long-term), (ii) 40°C/75% RH (intermediate), and (iii) 45°C/75% RH (accelerated). Samples were withdrawn at 0, 1, 3, and 6 months and analyzed for pH, viscosity, colour, odour, acid value, and peroxide value. Phase separation and rancidity were also visually assessed [21].

Results and Discussion

4.1 Organoleptic and Physicochemical Evaluation

The organoleptic and physicochemical parameters of all three formulations (F1, F2, F3) are presented in Table 2. All formulations exhibited characteristic herbal odour attributed primarily to the essential oil components of curry leaves and rosemary, and to the volatile terpenoids of nagarmotha. The colour progressively deepened from F1 (pale yellow) to F3 (dark brown) with increasing extract concentrations, consistent with the high phenolic and flavonoid content of amla and hibiscus extracts [7, 9]. The pH values of F1, F2, and F3 were 5.8 ± 0.05 , 5.5 ± 0.04 , and 5.2 ± 0.06 , respectively, all within the acceptable

range of 4.5–7.0 for scalp application. The slightly acidic pH mimics the physiological scalp pH (4.5–5.5), thereby supporting the integrity of the hair cuticle and minimizing disruption of the scalp's acid mantle [16]. The progressive decrease in pH with increasing extract concentration is attributable to the higher content of organic acids, particularly ascorbic acid from Amla and gallic acid from Nagarmotha and Amla [7].

Viscosity values ranged from 42.3 ± 1.2 mPa·s (F1) to 55.1 ± 1.8 mPa·s (F3), within the acceptable specification of 30–80 mPa·s for hair oils. The higher viscosity of F2 and F3 compared to F1 is attributable to the elevated concentration of semi-solid herbal extracts, which contribute to the overall rheological profile. F2 demonstrated the most optimal spreadability and scalp coverage during in-use assessment [17]. Specific gravity and refractive index values were consistent across formulations and within the IP 2022 specifications for fixed oils. Acid values (≤ 1.35 mg KOH/g) and peroxide values (≤ 1.72 meq/kg) were well below the permissible limits (AV ≤ 2.0 ; PV ≤ 5.0), confirming good oxidative stability at baseline [19].

Table 2: Physicochemical evaluation parameters of polyherbal hair oil formulations (n=3, Mean $\pm$ SD)

Parameter	F1	F2	F3	Standard/Limit
Colour	Pale yellow	Light brown	Dark brown	Characteristic
Odour	Mild herbal	Moderate herbal	Strong herbal	Pleasant, characteristic
Taste	Slightly bitter	Moderately bitter	Bitter	Characteristic
pH (25°C)	5.8 ± 0.05	5.5 ± 0.04	5.2 ± 0.06	4.5–7.0
Viscosity (mPa·s, 25°C)	42.3 ± 1.2	48.7 ± 1.5	55.1 ± 1.8	30–80 mPa·s
Specific Gravity	0.912 ± 0.003	0.918 ± 0.002	0.924 ± 0.004	0.9–0.95
Refractive Index	1.459 ± 0.001	1.462 ± 0.001	1.465 ± 0.002	1.45–1.47
Acid Value (mg KOH/g)	1.12 ± 0.08	1.24 ± 0.10	1.35 ± 0.09	≤ 2.0
Peroxide Value (meq/kg)	1.45 ± 0.12	1.58 ± 0.14	1.72 ± 0.15	≤ 5.0

All values are mean $\pm$ SD, n = 3; pH measured as 10% v/v dispersion in distilled water.

Stability Analysis

Accelerated stability testing is critical for predicting the shelf life and performance of cosmeceuticals formulations under real-world storage conditions. Results of the stability study at 40°C/75% RH over 6 months are summarized in Table 3. All three formulations remained physically stable over the six-

month study period, with no observed phase separation, precipitation, or gross rancidity. Minor darkening of colour was noted in F2 at 3 months at 40°C, likely due to Maillard type browning reactions between amino acids from fenugreek and reducing sugars from amla extract; however, this change was within acceptable organoleptic limits and did not affect product performance [20]. pH values remained within the specified range throughout the study period, with maximum deviations of 0.08 pH units, indicating adequate buffering capacity conferred by

the phenolic acids and organic acids within the extracts. Viscosity showed marginal increases (< 5%) at elevated temperatures for F2 and F3, consistent with increased intermolecular interactions between the phytoconstituents at higher temperatures [17]. Acid values and peroxide values showed small but statistically non-significant increases over time, remaining well below established safety thresholds. The inclusion of Vitamin E and BHT as antioxidants

effectively retarded oxidative degradation of the unsaturated fatty acids in coconut oil, consistent with published literature [13, 21]. F2 demonstrated the most favorable overall stability profile, combining adequate herbal extract concentration for pharmacological efficacy with excellent physicochemical stability over the six-month accelerated study period.

Table 3: Accelerated stability testing results at 40°C/75% RH over 6 months

Parameter	Initial	F1 (3 mo)	F2 (3 mo)	F3 (3 mo)	F1 (6 mo)	Acceptable?
pH	5.2–5.8	5.75	5.48	5.18	5.71	Yes
Viscosity	42–55	43.1	49.3	56.2	44.0	Yes
Colour	Characteristic	No change	Slight darkening	No change	No change	Yes
Odour	Characteristic	Unchanged	Unchanged	Unchanged	Unchanged	Yes
Acid Value	1.12–1.35	1.14	1.27	1.38	1.18	Yes
Phase Separation	Absent	Absent	Absent	Absent	Absent	Yes

mo = months; stability conditions: 40°C/75% RH (ICH Q1A(R2) intermediate condition).

Pharmacological Basis of Selected Herbs

Nagarmotha (*Cyperus rotundus*): The rhizome contains sesquiterpenoids (cyperene, patchoulene, mustakone), flavonoids, and alkaloids that exhibit potent antifungal activity against *Malassezia furfur*, the primary pathogen in dandruff, as well as anti-inflammatory properties mediated via COX-2 inhibition [8].

Curry Leaves (*Murraya koenigii*): The leaves are rich in carbazole alkaloids (mahanimbine, koenigine), monoterpenes, and flavonoids which have demonstrated significant hair growth-promoting activity in murine models, possibly via upregulation of vascular endothelial growth factor (VEGF) in the dermal papilla [9].

Amla (*Phyllanthus emblica*): One of the richest natural sources of ascorbic acid (Vitamin C) and tannins, Amla has demonstrated potent 5 α -reductase inhibitory activity, antioxidant protection of hair follicle cells, and collagen synthesis promotion, making it particularly valuable for androgenetic alopecia management [7].

Hibiscus (*Hibiscus rosa-sinensis*): Hibiscus flowers and leaves contain anthocyanins, flavonoids, mucilage, and saponins that collectively enhance scalp microcirculation, impart conditioning to the hair shaft, and exhibit anti-DHT (dihydrotestosterone) activity relevant to alopecia prevention [10].

Fenugreek (*Trigonella foenum-graecum*): Fenugreek seeds are rich in steroidal saponins (diosgenin, trigonelline), proteins (44% protein content), and nicotinic acid, which strengthen the hair shaft, reduce hair breakage, and impart a natural lustre. Diosgenin is structurally related to DHEA and may modulate hormonal pathways involved in hair loss [11].

Coconut Oil: Virgin coconut oil, with a high lauric acid content ($\approx 49\%$), has a unique affinity for hair proteins and penetrates the hair shaft more effectively than mineral oil or sunflower oil, significantly reducing protein loss from both damaged and undamaged hair. Its antimicrobial and emollient properties further support scalp health maintenance [13].

CONCLUSION

The present study successfully developed and evaluated three polyherbal hair oil formulations (F1, F2, F3) incorporating Nagarmotha, Curry Leaves, Amla, Hibiscus, and Fenugreek extracts in a virgin coconut oil base. All formulations passed organoleptic and physicochemical evaluation parameters including pH, viscosity, specific gravity, refractive index, acid value, and peroxide value. Accelerated stability testing over six months confirmed that all formulations were physically and chemically stable under ICH-recommended storage conditions, with F2 demonstrating the optimal balance between herbal extract concentration and long-term stability. The formulations showed promise as natural alternatives or adjuncts to synthetic hair care products for the promotion of hair growth, prevention of hair fall, and management of scalp disorders. Future studies should include in vitro hair growth promotion assays, clinical evaluation in human volunteers, microbial challenge testing, and pharmacokinetic studies of key phytochemicals to substantiate the pharmacological claims and establish formal shelf-life data for regulatory submissions.

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