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POLYHERBAL HAIR OILS: A REVIEW ON FORMULATION TECHNIQUES AND EVALUATION PARAMETERS

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ABSTRACT

Hair oils are widely used for scalp care, lubrication and conditioning of the hair shaft, while medicinal plants remain an important source of ingredients for traditional and contemporary cosmetic preparations. A polyherbal hair oil combines selected botanicals with one or more carrier oils to obtain complementary conditioning, antioxidant, soothing or antimicrobial properties. Rational selection of plants is essential because the chemical composition and evidence base vary substantially between species, plant parts and extraction methods. This narrative review discusses the biological structure and growth cycle of hair, common scalp and hair disorders, phytochemical groups relevant to hair care, and the potential contribution of ten medicinal plants: Bhringraj, Amla, Neem, Hibiscus, Brahmi, Fenugreek, *Aloe vera*, Curry leaves, Jatamansi and Rosemary. Available evidence ranges from traditional use and in vitro observations to animal experiments and a small number of human studies; it does not establish the clinical effectiveness of a single standardized polyherbal hair-oil formulation. Pharmaceutical development therefore requires suitable oil-base selection, controlled extraction and incorporation, compatibility assessment, and evaluation of organoleptic, rheological, physicochemical, oxidative, microbial and stability attributes. Particular attention is required when aqueous or mucilage-rich materials are incorporated into an otherwise

anhydrous oil system. The review also considers safety, raw-material authentication, standardization, packaging and emerging delivery approaches. Polyherbal hair oil may offer useful cosmetic conditioning and a platform for evidence-led botanical development, but therapeutic claims for alopecia, dandruff or premature greying require product-specific clinical validation.

KEYWORDS: Polyherbal hair oil; Herbal formulation; Hair growth; Phytochemicals; Scalp care; Pharmaceutical evaluation.

INTRODUCTION

Hair is a specialized keratinized appendage of the skin and contributes to protection, thermoregulation, sensory perception and social identity. Each hair is produced by a follicular mini-organ embedded in the dermis, while the visible shaft above the skin surface consists of compact, keratin-rich cells that are no longer metabolically active. The follicle contains epithelial and mesenchymal compartments, including a dermal papilla and stem-cell niches, which coordinate repeated cycles of hair production, regression and rest. Because hair appearance depends on both follicular biology and the physical condition of the exposed fibre, scalp care and hair-shaft conditioning should be considered related but distinct objectives.[1,2]

Hair and scalp concerns are common and include increased shedding, patterned hair loss, dandruff, dryness, breakage, irritation and premature greying. Their causes are diverse: androgen-dependent follicular miniaturization, altered hair-cycle timing, inflammation, genetic predisposition, nutritional or endocrine factors, microbial and barrier interactions, cosmetic damage and ageing may contribute in different combinations. Dandruff and seborrhoeic dermatitis are associated with interactions between Malassezia yeasts, sebum, epidermal barrier function and host inflammatory responses. Premature greying is also multifactorial and involves genetic influences, melanocyte dysfunction and oxidative processes. A cosmetic oil can improve lubrication or reduce friction, but this does not mean it can correct the underlying cause of every hair or scalp disorder.[2,3]

Conventional hair-care products include shampoos, conditioners, serums, styling preparations and medicated scalp products. These products are designed for different purposes: cleansing, detangling, reduction of friction, moisturization, cosmetic appearance or delivery of an approved active ingredient. Frequent chemical processing, high-temperature styling, unsuitable cleansing practices and poorly selected products may contribute to dryness, cuticle

disruption or irritation in susceptible users. However, synthetic origin alone does not establish that a product is harmful, just as botanical origin does not guarantee safety or efficacy. The selection of any hair-care preparation should depend on its composition, intended use, quality and user tolerance.[2,4]

Medicinal plants have a long history of use in hair-care traditions, including topical oiling, herbal washing preparations and plant-based pastes. Bhringraj, Amla, Neem, Hibiscus, Brahmi, Fenugreek, *Aloe vera*, Curry leaves, Jatamansi and Rosemary are among the botanicals discussed in traditional practice or contemporary research. Their extracts may contain polyphenols, flavonoids, tannins, terpenoids, saponins, alkaloids, volatile constituents, polysaccharides and fixed oils. These groups may show antioxidant, antimicrobial, anti-inflammatory, emollient or film-forming properties in selected experimental systems. Nevertheless, an observed in vitro activity or a traditional use does not, by itself, demonstrate a clinically meaningful effect on human hair growth.[4]

The pharmaceutical development of a polyherbal hair oil involves more than mixing plant powders with a vegetable oil. Botanical authentication, selection of the correct plant part, controlled drying, extraction, filtration, selection of compatible excipients, microbial risk management, physicochemical evaluation and stability testing are all important. The formulation should also be reproducible across batches and packaged in a container that limits light, oxygen and moisture exposure. Safety considerations include irritation, sensitization, microbial contamination from incompletely dried botanicals, and the potential for oxidation products to form during storage.[4]

MATERIALS AND METHODS

This article was prepared as a narrative review of literature relevant to hair biology, botanical hair-care ingredients and pharmaceutical development of polyherbal hair oils. Literature was identified through targeted searches of PubMed/MEDLINE records, journal-publisher websites and relevant scientific and standards organizations. Search concepts included combinations of the terms “polyherbal hair oil,” “herbal hair formulation,” “hair growth,” “hair follicle,” “hair cycle,” “alopecia,” “dandruff,” “scalp care,” “Eclipta alba,” “Phyllanthus emblica,” “Hibiscus rosa-sinensis,” The same concepts may be used to update searches in Google Scholar, Scopus and ScienceDirect before submission; this draft does not claim a complete database-by-database systematic search. [1-4]

Priority was given to peer-reviewed research articles, narrative and systematic reviews, human clinical studies, preclinical investigations with clearly described models, and

authoritative publications on herbal-material quality and cosmetic microbiology. Publications were selected for relevance to botanical identity, plant-part selection, phytochemical composition, hair-fibre conditioning, follicular biology, topical safety, extraction and incorporation methods, and evaluation of oil-based products. Older studies were retained when they represented direct experimental evidence for a specific botanical or carrier oil, while recent reviews were used to contextualize newer evidence and identify limitations. [4-20]

RESULTS AND DISCUSSION

1. OVERVIEW OF HAIR STRUCTURE AND HAIR GROWTH

1.1 Structure of the hair shaft and follicle

The hair shaft is commonly described as having three concentric components: the cuticle, cortex and, in many terminal hairs, a central medulla. The cuticle is composed of overlapping scale-like cells that protect the inner fibre and influence surface friction, shine and combability. The cortex forms the bulk of the shaft and contains keratin intermediate filaments, associated proteins and pigment granules; it largely determines tensile strength, elasticity and colour. The medulla is a variably present central region and is less important to the mechanical properties of fine hair. Because the exposed shaft is non-living tissue, cosmetic products act mainly through surface deposition, lubrication, reduction of friction or limited penetration of selected lipid materials rather than by biologically repairing the shaft. [1,4,19]

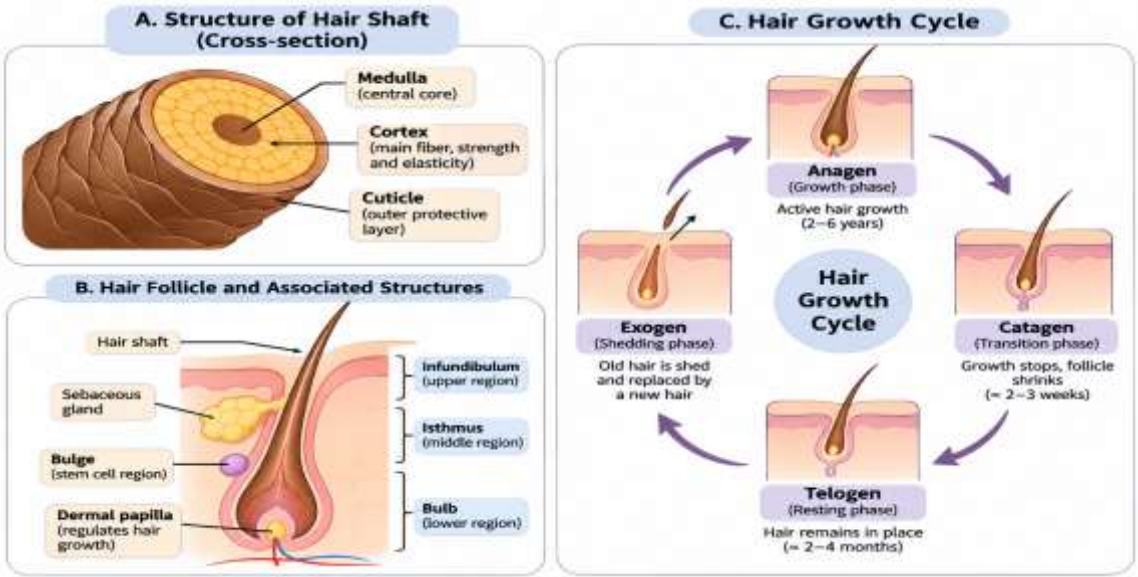


Figure 1: Overview of Hair Structure and Hair Growth.

2. COMMON HAIR AND SCALP DISORDERS

Hair fall is a symptom rather than a single diagnosis. Normal shedding occurs as part of the hair cycle, but persistent or visibly increased shedding may arise from telogen effluvium, androgenetic alopecia, alopecia areata, traction, inflammatory scalp disease, nutritional deficiencies, medication exposure or scarring disorders. The appropriate response depends on identifying the cause and, where needed, obtaining dermatological assessment. Hair oils can reduce friction and improve the feel of dry fibres; they have not been shown to replace evidence-based management of clinically diagnosed alopecia. A formulation intended for cosmetic conditioning should therefore avoid claims to cure baldness or restore follicles without product-specific clinical data.[1,2,4]

Dandruff is characterized by visible scalp flaking, often with itching and variable erythema. It overlaps with, but is not identical to, seborrhoeic dermatitis. Malassezia yeasts are part of the normal scalp microbiota, yet their interaction with sebum composition, epidermal barrier function and host inflammatory response can contribute to flaking in susceptible individuals. A botanical ingredient with antifungal activity in a laboratory assay may be of research interest, but an oil formulation has to demonstrate appropriate activity, scalp tolerability and clinical benefit. In some individuals, heavy or occlusive products may worsen discomfort or accumulation, so product suitability should be assessed rather than assumed.[3,4]

Scalp irritation may result from inflammatory dermatoses, fragrances, preservatives, surfactants, essential oils, botanical allergens or inappropriate product use. Repeated application of concentrated essential oils or uncharacterized plant extracts can cause irritant or allergic contact reactions. Premature greying is influenced by genetic and cellular factors, including reduced melanocyte function and oxidative damage within the follicular pigmentary unit. At present, evidence-based treatments capable of reliably restoring prematurely grey hair remain limited. A hair oil may provide cosmetic conditioning or colour-associated effects when it contains pigments, but it should not be promoted as reversing the biological process of canities without appropriate clinical evidence.[2-4]

3. CONCEPT AND IMPORTANCE OF POLYHERBAL HAIR OIL

A polyherbal hair oil is a topical oil-based preparation containing two or more medicinal plant materials, extracts or phytochemical-rich fractions dispersed or dissolved in a carrier-oil system. The formulation may use whole dried plant materials, filtered oil infusions, concentrated extracts or standardized ingredients. The oil base acts as a vehicle and provides lubrication and emollience, while the botanical components are selected for a defined

rationale such as antioxidant potential, scalp comfort, conditioning, fragrance or antimicrobial activity. The term polyherbal describes composition; it does not in itself imply that the formulation is synergistic, therapeutically effective or safer than a single-ingredient preparation.[4,11]

Potential limitations include variability in raw botanical material, uncertain concentration of marker compounds, incompatibility between polar and non-polar extracts, colour and odour changes, sedimentation, oxidation and difficulty in attributing adverse reactions to an individual component. A formulation containing multiple plants may also complicate regulatory classification and safety assessment. Therefore, a small number of well-characterized ingredients with complementary and testable functions can be preferable to an unnecessarily complex mixture. Synergy should be treated as a hypothesis and tested using appropriate comparators and validated endpoints.[4,11]

4. MEDICINAL PLANTS USED IN POLYHERBAL HAIR OIL

4.1 Bhringraj (Eclipta alba / Eclipta prostrata)

Bhringraj is widely used in Ayurvedic hair-care preparations. The botanical name *Eclipta alba* is commonly encountered in older pharmacological literature, while *Eclipta prostrata* is also used as an accepted name in contemporary taxonomic sources. Reported constituents include coumestans such as wedelolactone and demethylwedelolactone, flavonoids and other phenolic or terpenoid constituents. In a mouse model, a methanolic whole-plant extract produced dose-related changes in hair-growth-associated endpoints, and a separate study reported follicular keratinocyte proliferation and altered TGF-β1 expression in nude mice. These are preclinical findings and do not demonstrate efficacy in people or establish the performance of an oil infusion.[5,6]

4.2 Amla (Phyllanthus emblica)

Amla fruit contains hydrolysable tannins and polyphenols, including emblicanin-related compounds, gallic acid, ellagic acid, corilagin and other phenolic constituents; flavonoids and organic acids have also been reported. These constituents provide a rationale for investigating antioxidant activity and for using the fruit in traditional hair-care products. A randomized controlled trial evaluated an oral Amla-containing product in women with female androgenetic alopecia and reported changes in selected hair parameters over 12 weeks. Because the product was administered orally, that result cannot be used as direct evidence that topical Amla oil increases hair growth.[7,8]

4.3 Neem (Azadirachta indica)

Neem leaves, bark and seed-derived materials contain diverse secondary metabolites, including limonoids such as azadirachtin, nimbin and nimbolide, as well as flavonoids, phenolic compounds and other terpenoids. Neem has been investigated for antimicrobial, antifungal, anti-inflammatory and antioxidant activities in experimental systems. These properties explain its traditional use in scalp-care preparations, particularly products intended for cleansing or maintaining scalp comfort. However, the available literature does not establish that neem-containing hair oil treats dandruff or prevents alopecia in clinical practice.[4,9]

4.4 Hibiscus (Hibiscus rosa-sinensis)

Hibiscus flowers and leaves contain flavonoids, anthocyanins, tannins, saponins, terpenoids, mucilage and other phenolic constituents. Their mucilage-rich character provides a traditional rationale for conditioning and improving the feel of hair preparations, while the polyphenol content supports investigation of antioxidant activity. A published in vivo and in vitro study examined petroleum-ether extracts of leaves and flowers and reported hair-growth-related observations in an animal model. This evidence remains preclinical and cannot be interpreted as proof of hair regrowth in humans.[10,11]

4.5 Brahmi (Bacopa monnieri)

Brahmi is a traditional Ayurvedic plant containing dammarane-type triterpenoid saponins, including bacosides, bacopasides and related glycosides. Published reviews describe antioxidant and anti-inflammatory activities in experimental models, but the available evidence is mainly directed toward neurological or general pharmacological applications rather than topical hair growth. Consequently, the presence of Brahmi in a hair oil is primarily supported by traditional use and a possible supportive phytochemical rationale, not by robust clinical evidence for alopecia.[4,12]

4.6 Fenugreek (Trigonella foenum-graecum)

Fenugreek seeds contain galactomannan-rich mucilage, proteins, fixed oil, steroidal saponins and sapogenins such as diosgenin, together with trigonelline, flavonoids and other phenolic compounds. The mucilage and protein fractions may contribute to film-forming or conditioning effects in water-containing preparations, while seed lipids may be relevant to an oil-based system. Antioxidant and anti-inflammatory activities have been reported for selected fenugreek extracts, but the evidence does not demonstrate that fenugreek seed oil or a polyherbal mixture reliably reverses hair loss.[4,13]

4.7 Aloe vera (Aloe vera)

Aloe vera inner-leaf gel contains polysaccharides, particularly acetylated mannans such as acemannan, along with sugars, glycoproteins and minor phenolic or anthraquinone-related constituents depending on the plant part and processing. Aloe preparations have been investigated for moisturizing, soothing and wound-care applications. These properties may support scalp comfort in suitable formulations, but evidence for direct stimulation of human hair growth is insufficient. Aloe gel is predominantly aqueous and is not miscible with a simple vegetable-oil base without an emulsification strategy.[4,14]

4.8 Curry leaves (Murraya koenigii)

Curry leaves are used traditionally in hair oils and contain carbazole alkaloids, including mahanimbine and related compounds, as well as volatile constituents, flavonoids and phenolic compounds. Reviews describe antioxidant and anti-inflammatory activities for selected leaf extracts and isolated compounds. The traditional use of curry leaves is relevant to the cultural context of polyherbal hair oil, but direct controlled clinical evidence for hair growth or prevention of premature greying remains limited.[4,15]

4.9 Jatamansi (Nardostachys jatamansi)

Jatamansi is a Himalayan medicinal plant whose rhizomes contain sesquiterpenes and related volatile constituents, including jatamansone (valeranone) and other structurally related compounds. Pharmacological reviews describe antioxidant, antimicrobial and neurobiological activities in selected experimental settings. The plant has a traditional role in aromatic and Ayurvedic preparations, but direct evidence supporting topical hair-growth activity is not established. It should therefore be regarded as a traditional or exploratory ingredient rather than a clinically validated anti-alopecia agent.[4,16]

4.10 Rosemary (Salvia rosmarinus; synonym Rosmarinus officinalis)

Rosemary leaves and essential oil contain volatile constituents such as 1,8-cineole, α-pinene, camphor and borneol, while non-volatile extracts may contain rosmarinic acid, carnosic acid and carnosol. A randomized comparative trial evaluated topical rosemary oil against 2% minoxidil in adults with androgenetic alopecia over six months and reported increases in hair count from baseline in both groups at the later assessment. The study is a useful human signal, but it was a single product-specific trial and does not establish that rosemary is equivalent to minoxidil or that a rosemary-containing polyherbal oil will produce the same result.[17,18]

5. PHYTOCHEMICAL CONSTITUENTS AND THEIR ROLE IN HAIR CARE

TABLE 1. MAJOR PHYTOCHEMICAL CONSTITUENTS AND THEIR POTENTIAL ROLE IN HAIR CARE.

Phytochemical group	Representative constituents	Potential role in hair care	Limitations / formulation considerations
Flavonoids	Quercetin, kaempferol, luteolin and related flavonoids.	Antioxidant and anti-inflammatory activity in experimental systems; potential support for scalp-care products.	Activity is concentration- and extract-dependent; human follicular benefit is unproven.[8-11,14,15,18]
Tannins	Emblicanins, gallic acid derivatives, ellagitannins and related polyphenols.	Antioxidant and astringent properties; may influence surface feel and oxidative stability.	High or variable levels may affect colour, texture and compatibility.[8,11]
Alkaloids / limonoids	Carbazole alkaloids in curry leaf; azadirachtin, nimbin and related Neem limonoids.	Reported antimicrobial, antioxidant or anti-inflammatory activities.	Distinct classes with different solubility; do not assume equivalent activity in an oil base.[9,15]
Saponins	Bacosides, bacopasides and Fenugreek steroidal saponins.	Potential surface-active and pharmacological properties; may be relevant to extract design.	Many are polar and may be poorly extracted into neat vegetable oil.[12,13]
Terpenoids	Jatamansone/valeranone, rosemary terpenes and Neem terpenoid constituents.	Aromatic, antioxidant or antimicrobial potential in selected extracts.	Volatility, oxidation and irritation potential require control.[9,16-18]
Essential oils	Rosemary volatile oil and other aromatic fractions.	Fragrance and in vitro antimicrobial potential.	Concentrated essential oils may irritate or sensitize; safe level and stability need evaluation.[17,18,25]
Phenolic compounds	Rosmarinic acid, carnosic acid, gallic acid, ellagic acid and other phenolics.	Antioxidant activity and potential protection against oxidative deterioration.	Polar compounds may not partition well into oils; assay and marker selection are important.[8,18]
Polysaccharides / mucilage	Acemannan, galactomannan and plant mucilage.	Hydration, soothing and film-forming potential in water-containing systems.	Require compatibility or emulsification; water can increase microbial risk.[13,14,21-24]

Phytochemical group	Representative constituents	Potential role in hair care	Limitations / formulation considerations
Fixed oils and fatty acids	Lauric-, oleic- and linoleic-rich vegetable oils.	Lubrication, emollience and reduced hair-fibre protein loss for selected oils.	Conditioning effects should not be described as follicular hair-growth stimulation.[10,19]

6. MECHANISM OF ACTION OF HERBAL INGREDIENTS IN HAIR CARE

Antioxidant activity is one of the most frequently proposed mechanisms for botanical hair-care ingredients. Reactive oxygen species can participate in inflammatory responses and damage cellular components when their production exceeds antioxidant capacity. Polyphenols from Amla, Hibiscus, Neem and Rosemary, together with other plant constituents, may reduce oxidation in chemical assays or experimental systems. Such observations do not establish that the same compounds reach the follicular target after topical application. Their stability in the carrier oil, release from the formulation, partitioning into the scalp and local concentration need to be characterized before a follicular antioxidant mechanism can be proposed with confidence.[8,9,11,18]

Anti-inflammatory activity may be relevant when scalp discomfort or irritation is part of the intended product rationale. Selected plant extracts have been reported to modulate inflammatory mediators in experimental models, and this may support further study of Neem, Rosemary, Hibiscus or other phenolic-rich botanicals. Nevertheless, a cosmetic oil is not automatically an anti-inflammatory treatment. Clinical scalp conditions such as seborrhoeic dermatitis, psoriasis or inflammatory alopecia require diagnosis and condition-specific care; a hair oil should not be promoted as a substitute for medical treatment.[3,4,9,11,18]

Antimicrobial and antifungal activity is another possible function of botanical ingredients. Neem and selected essential-oil components have been investigated against microorganisms, including fungi. In the context of dandruff, the relationship between Malassezia, sebum and the host scalp barrier is complex. A meaningful formulation claim would require testing the finished product using appropriate strains, validated methods and suitable controls, followed by clinical evaluation. Results from a concentrated extract or pure compound cannot be directly transferred to a diluted polyherbal oil because the carrier matrix may change availability and activity.[3,9,17,18]

Potential follicular effects are biologically distinct from conditioning of the hair shaft. Animal studies of Eclipta extracts have described changes in hair-cycle-associated observations, follicular keratinocyte proliferation and expression of markers such as TGF-β1.

Hibiscus extracts have also been examined in animal models. These findings offer mechanistic hypotheses, but species differences, extract composition, dose, treatment site and the limitations of animal hair-cycle models constrain translation to human scalp follicles. No direct clinical evidence demonstrates that a standardized polyherbal oil containing these ingredients reliably induces anagen in humans.[5,6,10]



Figure 2: Proposed mechanisms relevant to herbal hair care.

7. FORMULATION DEVELOPMENT OF POLYHERBAL HAIR OIL

7.1 Selection and processing of herbal ingredients

Ingredient selection should begin with the intended function of the product and the quality of the supporting evidence. Plants should be authenticated by a qualified taxonomist or pharmacognosist, and the accepted botanical name, family, plant part, source, collection date and voucher specimen details should be recorded. Raw materials should be checked for identity, foreign matter, moisture, infestation, microbial load and relevant contaminants. Good agricultural and collection practices support traceability and reduce variation associated with harvesting, drying and storage.[21,22]

After authentication, plant materials are cleaned, dried under conditions suitable for the plant part and reduced to a controlled particle size. Drying should limit enzymatic degradation, microbial growth and loss of volatile constituents. The material should be stored in closed, labelled containers protected from heat, light, moisture and pests. Each botanical should have

a defined specification, including organoleptic characteristics and, where justified, chromatographic fingerprints or marker-compound ranges. Mixing uncharacterized powders from multiple suppliers can produce large batch-to-batch variations.[21,22]

7.2 Selection of oil bases

Coconut oil is frequently used because of its spreadability, sensory acceptability and evidence for reducing protein loss from hair fibres under selected application conditions. Sesame oil contains a mixture of oleic, linoleic and other fatty acids, together with minor antioxidant constituents, and is used traditionally in topical preparations. Almond oil is valued as an emollient and contains oleic and linoleic acid-rich triglycerides. Castor oil is more viscous and contains a high proportion of ricinoleic acid, which can alter the feel and spreading behaviour of a blend. These carrier oils primarily provide vehicle and conditioning functions; their use should not be equated with proven stimulation of follicular growth.[10,19]

The selection of a single oil or blend should consider viscosity, oxidation susceptibility, odour, skin feel, cost, supply quality and compatibility with the selected herbal ingredients. Polyunsaturated oils may be more susceptible to oxidative deterioration than more saturated oils, while highly viscous oils may impair spreading or leave an undesirable residue. A blend can be designed to balance these properties, but the ratios should be optimized through preformulation experiments rather than adopted from an unrelated published batch. The carrier oil should also meet appropriate identity and purity specifications.[19-22]

7.3 Extraction and incorporation of herbal ingredients

The extraction method determines which constituents are recovered and therefore affects both the activity and physical behaviour of the formulation. Traditional oil infusion involves contacting dried plant material with a carrier oil for a defined period, sometimes with gentle heating, followed by filtration. Hot maceration can accelerate extraction but may degrade heat-sensitive phenolics or volatile substances if temperature and time are excessive. Cold maceration avoids thermal stress but may require longer contact and may provide lower extraction efficiency. The method should be selected according to the chemical nature of the target constituents and validated for reproducibility.[4,11,20-22]

Filtration is important for removing plant fragments and suspended matter that can affect appearance, sedimentation, spreadability and user acceptability. The filtration method should not selectively remove the intended active constituents or cause excessive product loss. A final product may require a defined polishing step, deaeration and filling under controlled conditions. If antioxidants such as tocopherol or a standardized plant antioxidant are added to delay oxidation, their compatibility and contribution should be tested rather than assumed.

Fragrance materials and essential oils should be selected at safe levels and should not obscure the characteristic odour of deteriorated oil.[18-22,25]

TABLE 2. COMMON INGREDIENTS USED IN POLYHERBAL HAIR OIL AND THEIR FUNCTIONS.

Ingredient	Formulation role	Purpose / contribution	Key considerations
Coconut oil	Carrier oil / emollient	Provides lubrication and may reduce hair-fibre protein loss under selected use conditions.	Monitor odour, oxidation and batch identity; not a proven follicular stimulant.[10,19]
Sesame oil	Carrier oil	Traditional topical vehicle with mixed fatty acids and minor constituents.	Assess viscosity, peroxide value, odour and supplier quality.[19,22]
Almond oil	Carrier oil / emollient	Improves slip and surface conditioning.	Check oxidation, allergen considerations and skin tolerance.[19,25]
Castor oil	Viscosity modifier / carrier oil	Contributes a high-viscosity, ricinoleic-acid-rich lipid phase.	May reduce spreading at high proportions; assess sensory profile.[19]
Dried herbal material	Botanical source	Provides plant-derived constituents through controlled infusion or extraction.	Authenticate plant part; control moisture, contaminants and particle size.[21,22]
Standardized herbal extract	Botanical active / marker source	May improve reproducibility compared with uncharacterized crude powder.	Check solvent residues, polarity, marker content and oil compatibility.[4,21,22]
Tocopherol or compatible antioxidant	Antioxidant excipient	May help delay oxidative deterioration of susceptible oils.	Select and justify the type and level; confirm effect in stability studies.[19,22]
Essential oil / fragrance	Sensory ingredient	Provides fragrance; selected volatile constituents may have in vitro antimicrobial activity.	Control concentration, oxidation and sensitization risk; perform safety assessment.[17,18,25]

8. METHODS OF PREPARATION OF POLYHERBAL HAIR OIL

In the traditional herbal infusion method, appropriately dried and authenticated plant materials are combined with a selected carrier oil and processed under controlled conditions. Some traditional approaches first prepare a water-based decoction of the botanicals and then

concentrate or transfer extractives into an oil phase. When water is used, the process must ensure adequate removal of residual moisture and should be designed to avoid microbial contamination or hydrolytic degradation. The exact process depends on the plant material and should be documented as a reproducible manufacturing procedure rather than described only as a household recipe.[11,12,21,22]

Hot maceration involves heating the carrier oil with the dried botanical material at a controlled temperature, followed by cooling and filtration. The method may shorten extraction time but can lead to loss of volatile compounds, oxidation of unsaturated lipids or degradation of heat-sensitive constituents if heating is prolonged. Temperature, duration, plant-to-oil ratio, particle size and mixing should therefore be defined and monitored. A temperature selected for one plant may not be appropriate for another, especially when volatile or thermolabile constituents are targeted.[18-22]

A general manufacturing sequence for development work is: authenticate and test raw plant materials; dry and mill where appropriate; prepare the selected extract or infusion; prepare and inspect the carrier-oil phase; incorporate the botanical fraction under controlled mixing; filter or clarify; conduct in-process checks; fill into a compatible, light-protective container; and initiate finished-product evaluation. This sequence is a process framework rather than a report of a formulation batch, and it does not specify or imply any experimentally established composition or yield.[11,21,22]

9. EVALUATION PARAMETERS OF POLYHERBAL HAIR OIL

Organoleptic evaluation includes the examination of colour, odour, appearance and general acceptability. It is a rapid preliminary assessment that can identify visible changes such as unexpected darkening, turbidity, sedimentation, phase separation or rancid odour. Colour and odour may vary naturally between batches because of differences in plant materials, but a defined product specification should describe an acceptable range. Organoleptic checks should be conducted at release and during stability testing using consistent lighting, containers and observation conditions.[11,21,22]

Homogeneity and physical appearance are assessed by observing the sample for uniformity, undissolved particles, sediment, flocculation or phase separation. A small amount may be spread on a clean glass surface or examined after gentle mixing to assess the distribution of the herbal fraction. Microscopic examination or centrifugation may be useful during development when suspended solids or instability are suspected. A formulation that settles

rapidly or contains coarse plant particles may provide inconsistent dosing and poor consumer acceptability.[11,21,22]

Spreadability indicates how readily the oil distributes over a defined surface under specified force and time. It may be assessed using a parallel-plate method or an appropriate instrumental technique, with sample mass, applied load, plate dimensions and time recorded. A high spreadability value is not automatically desirable because very low viscosity can cause run-off, while excessive viscosity may impair application. The result should be interpreted alongside viscosity, sensory performance and the intended use of the product.[11,19]

Acid value estimates the free fatty acid content of an oil and is commonly determined by titration with standardized alkali using an appropriate solvent system and endpoint indicator or potentiometric method. An increase may indicate hydrolysis or deterioration of the lipid phase. Peroxide value estimates primary oxidation products, particularly lipid hydroperoxides, and is determined using a validated iodometric or equivalent method. These values are useful for monitoring raw oil quality and oxidative changes during storage, but acceptance criteria should be established for the specific oil blend and applicable quality standard rather than borrowed without justification.[19,22]

Microbial quality testing should be based on the risk profile of the formulation. An anhydrous oil with low available water may present a lower microbial-growth risk than a water-containing emulsion, but dry herbal materials can introduce spores and contamination during manufacture. Microbiological limits should be appropriate to the product category and intended use. Preservative efficacy testing, where applicable, should be considered for products containing an aqueous phase or otherwise presenting microbial risk; the applicability of a challenge test depends on the formulation and relevant standards. Skin-compatibility testing, including validated in vitro approaches where suitable, is important for products intended for repeated scalp application.[21-25]



Figure 3: Preparation and evaluation workflow for polyherbal hair oil.

10. ADVANTAGES AND LIMITATIONS OF POLYHERBAL HAIR OIL

A well-designed polyherbal hair oil may provide convenient topical delivery of several botanical ingredients in a familiar dosage form. The carrier oils can lubricate the hair shaft, improve manageability and reduce friction, while selected plant extracts may contribute antioxidant, aromatic or soothing properties. A formulation can be tailored to specific consumer preferences such as light feel, conditioning performance or a traditional botanical profile. The ability to combine these functions is a formulation advantage, but the benefits must be confirmed through appropriate physicochemical, safety and product-performance testing.[4,10,11,19]

The limitations are equally important. Botanical composition can vary with species, plant part, geography, season, harvest and processing. Some phytochemicals are poorly soluble in oil, and complex extracts may cause colour, odour, sedimentation or oxidation problems. Essential oils and concentrated plant extracts can cause irritation or allergic contact dermatitis. Evidence for many plants is based on traditional use or preclinical studies rather than controlled clinical trials, and the presence of several ingredients does not guarantee greater activity. A polyherbal product should not be presented as a proven treatment for alopecia, dandruff or premature greying unless the finished formulation has been evaluated for the relevant indication.[2-4,17,18,25]

11. SAFETY, QUALITY CONTROL AND STANDARDIZATION

Quality assurance begins with authenticated raw materials and continues through extraction, formulation, filling and storage. Botanical identity should be confirmed using macroscopic and microscopic examination and, where appropriate, chromatographic or DNA-based methods. Raw materials should be assessed for foreign matter, moisture, microbial contamination, heavy metals, pesticide residues, mycotoxins and other contaminants according to their origin and risk profile. Good agricultural and collection practices improve traceability and reduce the chance of substitution or contamination, while pharmacognostic quality-control methods provide a framework for identity and purity testing.[21,22]

Standardization of extracts should include a defined botanical name, plant part, extraction solvent, drug-to-extract ratio, marker compounds, chromatographic fingerprint and batch-to-batch acceptance criteria. A single total-phenolic or total-flavonoid result may be insufficient to characterize a complex botanical mixture. Marker assays should be selected based on the extract's intended role and should use validated analytical methods. Finished products may require a multi-marker fingerprint because the composition of the whole oil can differ from the chemical profile of the raw extract after processing and storage.[4,21,22]

Safety assessment should consider the complete formulation, including carrier oils, botanical extracts, essential oils, antioxidants, fragrance ingredients and any emulsifiers or preservatives. Repeated scalp application may produce cumulative exposure, and individual botanicals may be irritants or sensitizers. The absence of a reported adverse effect in traditional use does not establish safety at concentrated extract levels. Product developers should evaluate local irritation and sensitization potential using suitable methods, review ingredient-specific safety information, and provide clear instructions for use and warnings where appropriate. Validated in vitro skin-irritation methods may contribute to a tiered safety strategy.[4,25]

CONCLUSION

Polyherbal hair oil represents a traditional and commercially familiar approach to topical hair care, combining selected medicinal plants with carrier oils to provide conditioning and other potential cosmetic functions. The reviewed botanicals contain diverse phytochemicals, including flavonoids, tannins, alkaloids, saponins, terpenoids, phenolic compounds, essential-oil constituents and polysaccharides. Their reported activities provide a scientific rationale for further investigation, but the strength of evidence is uneven. Bhringraj and Hibiscus have mainly preclinical hair-growth observations, while Rosemary and Amla have limited human

research that is specific to the tested product and route of administration. For several other plants, the rationale is based largely on traditional use or general pharmacological properties rather than established hair-growth efficacy. The conditioning effect of the carrier oil, particularly its influence on hair-fibre lubrication and protein loss, should be distinguished from biological stimulation of the follicle. Pharmaceutical development requires rational plant selection, authentication, controlled extraction, compatible oil-base selection, and reproducible manufacturing. Evaluation should cover appearance, homogeneity, viscosity, density, spreadability, acid value, peroxide value, refractive index, stability, microbial quality and skin compatibility, with pH assessment limited to formulations containing an aqueous phase or a defined aqueous dispersion. Raw-material standardization, contaminant control, oxidative stability and appropriate packaging are essential for product quality. Future research should prioritize well-characterized formulations, clear clinical indications, independent clinical trials and complete safety reporting. Longer-term studies should also assess user acceptability, scalp tolerability and batch-to-batch consistency under real-world storage conditions. A scientifically developed polyherbal hair oil may offer useful cosmetic benefits, but therapeutic claims should remain proportionate to the evidence available for the finished product.

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