Pharmacognostic, Phytochemical and Chromatographic Evaluation of a Fermented Rice Water-Based Polyherbal Hair Oil for Hair Growth Promotion

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***Abstract*—Hair loss and scalp disorders are among the most prevalent cosmetic concerns worldwide. The growing demand for natural hair care traditional and advanced products has encouraged the exploration of herbal formulations enriched with bioactive phytoconstituents. Fermented rice water is a traditional hair care remedy known for its rich composition of amino acids, vitamins, antioxidants, and minerals that contribute to good hair health.**

***Index Terms*—Fermented rice water, Gallic acid, Herbal cosmetics, Polyherbal hair oil, Pharmacognostic evaluation, Phytochemical screening, TLC fingerprinting.**

I. INTRODUCTION

Hair plays an important role in human appearance and self-esteem. Hair loss, dandruff, scalp irritation, and premature greying are common conditions that affect both men and women. [1] Conventional hair care products often contain synthetic chemicals that may produce undesirable effects upon prolonged use. Consequently, herbal formulations have gained popularity owing to their safety, efficacy, and consumer acceptance. [2]

Fermented rice water has been traditionally utilized in several Asian cultures for maintaining healthy hair. [3] Fermentation enhances the bioavailability of amino acids, vitamins, antioxidants, and organic acids, thereby improving its cosmetic potential.[4] Medicinal plants such as *Oryza sativa*, *Hibiscus rosa-sinensis*, *Eclipta prostrata*, *Trigonella foenum-graecum*, *Phyllanthus emblica*, and *Nigella sativa* have been extensively reported for their hair growth-promoting and scalp-protective properties.[5]

Despite the increasing commercialization of herbal hair oils, scientific standardization and quality control remain limited. [6] Therefore, the present study was undertaken to develop and evaluate a fermented rice water-based polyherbal hair oil using pharmacognostic, physicochemical, phytochemical, and chromatographic approaches. [7]

A. Rice Water

Rice (Oryza sativa) is a staple food for nearly half of the global population, particularly in Asia, where it provides a significant portion of daily caloric intake. Rice water—the liquid left after soaking or boiling rice—is commonly consumed but often discarded during food preparation. Rice bran oil is highly valued for its antioxidant-rich compounds, including ferulic acid, gamma-oryzanol, and phytic acid, making it a popular ingredient in the cosmetic industry and skincare treatments. Both natural and nano-encapsulated forms of rice bran oil and its extracts have been explored for their potential to protect against UVB radiation, treat skin conditions, and offer anti-aging benefits. [8]

B. *Hibiscus rosa-sinensis*

Hibiscus rosa-sinensis is a medicinally important plant rich in flavonoids, anthocyanins, tannins, saponins, and phytosterols. Its antioxidant, antimicrobial, anti-inflammatory, antidiabetic, and

hair growth-promoting properties make it a promising ingredient for herbal cosmetic and pharmaceutical formulations, particularly polyherbal hair oils and hair care products.[9]

C. Bhringraj

Eclipta prostrata (L.) L., commonly known as Bhringraj or False Daisy, is an annual medicinal herb belonging to the family Asteraceae. It is widely distributed throughout tropical and subtropical regions of Asia, Africa, and South America. Traditionally, the plant has been extensively used in Ayurveda and other traditional systems of medicine for the treatment of liver disorders, skin diseases, wound healing, and hair-related problems such as hair loss and premature greying. The plant contains several bioactive constituents, including wedelolactone, ecliptine, flavonoids, coumestans, and triterpenoid saponins, which contribute to its diverse pharmacological activities. [10]

D. Fenugreek seeds

Trigonella foenum-graecum L., commonly known as fenugreek or methi, is an annual herbaceous plant belonging to the family Fabaceae. It is widely cultivated in India, North Africa, the Mediterranean region, and other parts of the world for its culinary, nutritional, and medicinal value. Fenugreek seeds and leaves are rich sources of bioactive compounds such as alkaloids (trigonelline), steroidal saponins (diosgenin), flavonoids, galactomannans, and amino acids. Traditionally, fenugreek has been used in Ayurveda and other traditional systems of medicine for the management of diabetes, digestive disorders, inflammation, and hair-related problems. Due to its antioxidant, antimicrobial, anti-inflammatory, and hair growth-promoting properties, fenugreek is widely incorporated into herbal hair oils, shampoos, and cosmetic formulations. [11]

E. Amla

Phyllanthus emblica L., commonly known as amla or Indian gooseberry, is a deciduous tree belonging to the family Phyllanthaceae. It is native to the Indian subcontinent and has been widely used in Ayurveda, Unani, and traditional medicine systems for centuries. The fruit is highly valued for its rich nutritional profile, particularly its high vitamin C content, along with tannins, flavonoids, polyphenols, and gallic acid. Due to its potent antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory properties, amla is used in the management of various health conditions. In hair care formulations, *P. emblica* is recognized for promoting hair growth, strengthening hair follicles, reducing dandruff, and preventing premature greying, making it a key ingredient in herbal hair oils and cosmetic products. [12]

F. Kalonji / Black cumin

Nigella sativa L., commonly known as black seed, black cumin, or kalonji, is an annual flowering plant belonging to the family Ranunculaceae. It is native to South and Southwest Asia and has been widely used for centuries in traditional systems of medicine, including Ayurveda, Unani, and Arabic medicine. The seeds are rich in bioactive compounds such as thymoquinone, thymohydroquinone, p-cymene, flavonoids, alkaloids, and essential fatty acids, which contribute to their medicinal properties. Numerous studies have demonstrated the antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, and hepatoprotective activities of *N. sativa*. In hair care formulations, black seed is valued for its ability to nourish the scalp, strengthen hair follicles, reduce hair fall, and support healthy hair growth. [13]

II. MATERIALS AND METHODS

A. Collection and Authentication of Plant Materials

Fresh Hibiscus flowers, Bhringraj leaves, Fenugreek seeds, Amla fruits, and Kalonji seeds were procured from authenticated herbal suppliers.

B. Preparation of Fermented Rice Water

Rice grains were washed thoroughly and soaked in distilled water (1:3 ratio) for 24 h. The soaked rice water was incubated under controlled conditions for 48 h to facilitate fermentation. The fermented liquid was filtered and stored at 4°C until further use.

Fig 1. Fermented Rice Water

C. Preparation of Polyherbal Hair Oil

The formulation was prepared using the traditional Sneha Kalpana method. Coconut oil was used as the base oil. Fermented rice water and powdered herbal ingredients were incorporated and heated until complete evaporation of aqueous content. The oil was filtered and stored in amber-colored containers.

Table 1. Formulation Table of Fermented Rice water Polyherbal Hair Oil

S/n	Ingredient	Part Used	Quantity
1.	Fermented Rice Water	Fermented filtrate	20 mL
2.	*Hibiscus rosa-sinensis*	Dried flowers	5 g
3.	*Eclipta prostrata*	Dried leaves (Bhringraj)	5 g
4.	*Trigonella foenum-graecum*	Seeds (Fenugreek)	5 g
5.	*Phyllanthus emblica*	Dried fruits (Amla)	5 g
6.	*Nigella sativa*	Seeds (Kalonji)	5 g
7.	Coconut Oil	Base oil	60 mL
8.	Castor Oil	Co-base oil	10 mL

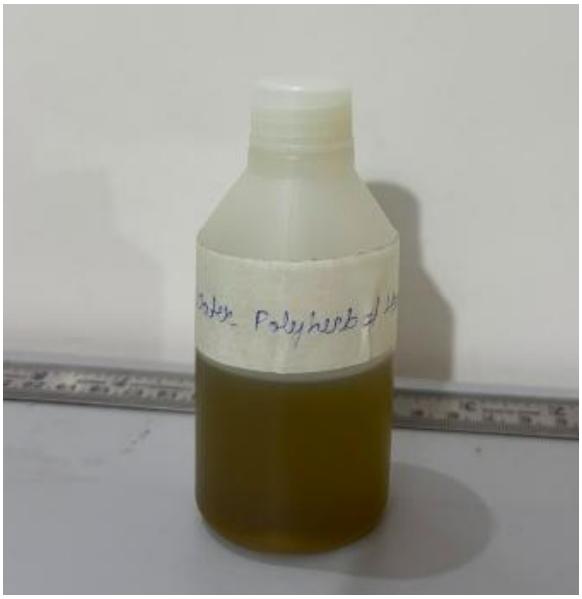

Fig 2. Fermented Rice Water Polyherbal Hair Oil

D. Pharmacognostic Evaluation

Macroscopic evaluation:

- Color,
- Odor,
- Texture,
- Organoleptic properties

Microscopic evaluation:

- Powder microscopy,
- Identification of diagnostic characters, Starch grains, Trichomes, Fibers
- Calcium oxalate crystals, Xylem vessels

E. Physicochemical Evaluation

The following parameters were evaluated:

- Specific gravity, Refractive index, Viscosity, pH, Acid value, Peroxide value, Saponification value, Iodine value

F. Preliminary Phytochemical Screening

Standard qualitative tests were performed for:

- Alkaloids, Flavonoids, Phenolic compounds, Tannins, Saponins, Terpenoids, Steroids, Glycosides

G. TLC Analysis

Sample Preparation: Methanolic extracts of the formulated oil were prepared and filtered.

Chromatographic Conditions:

Stationary Phase: Silica Gel 60 F254

Mobile Phase: Toluene:Ethyl acetate:Formic acid (5:4:1)

Application Volume: 10 µL

Detection Wavelengths: 254 nm

Marker Compound: Gallic acid

The chromatograms were analyzed for R_f values and peak area percentages.

III. RESULTS

Table 2. Organoleptic Characteristics of Polyherbal Hair Oil

Parameter	Observation
Colour	Dark Brownish Green
Odour	Characteristic Herbal
Appearance	Clear and Homogeneous
Texture	Smooth and Non-gritty
Phase Separation	Absent

Table 3. Microscopic Evaluation

Herbal Crude Drug	Biological Source and Family	Macroscopic Characters	Microscopic Diagnostic Features	Major Phytoconstituents
Hibiscus Flower (*Hibiscus rosa-sinensis*)	Dried flowers of *Hibiscus rosa-sinensis* Linn. F-Malvaceae	Large, showy red flowers; 5 petals; characteristic staminal tube; odour slight; mucilaginous taste.	Epidermal cells with wavy walls, abundant mucilage cells, calcium oxalate crystals, pollen grains spherical with spiny exine, multicellular trichomes.	Anthocyanins, flavonoids, quercetin, cyanidin glycosides, mucilage.
Bhringraj Leaves (*Eclipta prostrata*)	Leaves of *Eclipta prostrata* (L.) L. F-Asteraceae	Opposite, lanceolate leaves; green to dark green; rough surface; characteristic odour; slightly bitter taste.	Anomocytic stomata, multicellular covering trichomes, dorsiventral leaf, vascular bundles surrounded by parenchyma, calcium oxalate crystals.	Wedelolactone, demethylwedelolactone, ecliptine, flavonoids, alkaloids.
Fenugreek Seeds (*Trigonella foenum-graecum*)	Dried ripe seeds of *Trigonella foenum-graecum* Linn. F-Fabaceae	Hard, yellowish-brown, rhomboidal seeds with deep furrow; aromatic odour; bitter taste.	Thick testa, elongated palisade cells, mucilage-containing endosperm, aleurone grains, oil globules.	Diosgenin, trigonelline, galactomannan, saponins, flavonoids.
Amla Fruits (*Phyllanthus emblica*)	Dried fruits of *Phyllanthus emblica* Linn. F-Phyllanthaceae	Nearly spherical fruits; greenish-yellow to brown; six vertical furrows; sour and astringent taste.	Epicarp with cuticle, stone cells (sclereids), parenchyma containing tannins, calcium oxalate crystals, fibrovascular bundles.	Ascorbic acid, emblicanin A & B, gallic acid, ellagic acid, tannins.
Kalonji Seeds (*Nigella sativa*)	Dried seeds of *Nigella sativa* Linn. F-Ranunculaceae	Small, black, angular, trigonous seeds; aromatic odor; pungent bitter taste.	Thick-walled epidermis, pigmented testa, oil-bearing endosperm cells, aleurone grains, polygonal epidermal cells.	Thymoquinone, nigellone, fixed oils, alkaloids, saponins.

Table 4. Physicochemical Characteristics of Formulated Hair Oil

Parameter	Result
pH	5.82 ± 0.04
Specific Gravity	0.914 ± 0.003
Refractive Index	1.471 ± 0.002
Viscosity (cP)	33.24 ± 0.51
Acid Value (mg KOH/g)	1.68 ± 0.07
Peroxide Value (meq/kg)	2.31 ± 0.11
Saponification Value (mg KOH/g)	189.42 ± 2.84
Iodine Value	83.16 ± 1.74

Table 5. Phytochemical Evaluation of Formulation

Phytochemical Test	Tests	Observation
Alkaloids	Mayer's, Wagner's, Dragendorff's	+
Flavonoids	Shinoda, Alkaline Reagent, Lead Acetate	+++
Phenolic Compounds	Ferric Chloride, Lead Acetate	+++
Tannins	Ferric Chloride, Gelatin	++
Saponins	Foam, Emulsion	++

Steroids	Salkowski, Liebermann-Burchard	++
Terpenoids	Salkowski, Liebermann-Burchard	+++
Glycosides	Keller-Killiani, Molisch	++

(+ = Present, ++ = Moderately Present, +++ = Abundantly Present)

TLC Fingerprinting

Track 1 Track 2

Fig 3. Tracks of Standard and Polyherbal Hair Oil

Track 1: Gallic acid (Standard)
Track 2: Polyherbal Hair Oil (Fermented Rice water with Hibiscus, Bhringarj, Fenugreek, Amla and Kalonji)

Table 6. TLC Fingerprinting Rf values

Track	Sample	Spots	Rf Value
1	Gallic Acid (Standard)	1	0.64
		2	0.18
2	Polyherbal Hair Oil (Fermented Rice water with Hibiscus, Bhringarj, Fenugreek, Amla and Kalonji)	1	0.63
		2	0.16

Table 7. Stability Studies

Parameters	Initial	3 Months	6 Months
Colour	No Change	No Change	No Change
Odour	No Change	No Change	No Change
pH	5.82	5.80	5.77
Viscosity (cP)	33.24	32.96	32.61
Phase Separation	Absent	Absent	Absent

IV. DISCUSSION

A stable and phytochemically rich hair oil formulation was produced by combining fermented rice water with extracts from medicinal plants. It is well established that fermentation increases antioxidant activity and the availability of bioactive metabolites. The found potential for hair care may be attributed to the presence of flavonoids, phenolic compounds, and phytosterols. An essential analytical tool for standardisation and batch-to-batch uniformity is the well-established TLC fingerprint.

V. CONCLUSION

The developed fermented rice water-based polyherbal hair oil demonstrated satisfactory pharmacognostic, physicochemical, and phytochemical characteristics. The TLC fingerprint generated in this study may serve as a reliable quality control parameter for industrial production and future research. The formulation has potential application as a natural hair care product and further biological evaluation for hair growth promotion.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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