

Formulation and In Vitro Evaluation of Polyherbal Hair Spray for Enhancing UV Protection Activity

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ABSTRACT

The significant transition towards natural and sustainable personal care products requires the creation of effective botanical based substitutes for synthetic UV filters and antimicrobial agents. This research intercepts the dual issue of UV induced photodamage and fungal scalp infections *Malassezia* species/dandruff by formulating a novel polyherbal hair spray. Extracts from Rosemary (*Rosmarinus officinalis*), Butterfly Pea (*Clitoria ternatea*), Pomegranate (*Punica granatum*) peel, and Moringa (*Moringa oleifera*) all this were chosen for their established combination of antioxidant and antimicrobial properties. Three hydro alcoholic formulations (F1, F2, F3) were created and underwent thorough evaluation. Formulation F2 exhibited superior physicochemical stability (pH 4.31, low viscosity, high homogeneity) and provided outstanding biological activity. The calculated Sun Protection Factor SPF using the Mansur UV spectrophotometric method was found to be 15.0 ± 0.8 , categorizing it as a "high-protection" product. Additionally, F2 demonstrated the strongest in-vitro antifungal activity against *Candida albicans*, achieving a Zone of Inhibition (ZOI) of 22.5 mm through the Agar Well Diffusion Method. This synergistic formulation offers a stable, natural, and effective solution for combined photo protection and fungal protection of the hair and scalp.

Keywords: Polyherbal formulation, Hair spray, UV spectrophotometric, Antifungal activity, stability, Herbal cosmetics.

INTRODUCTION

In recent years, there has been a significant shift in consumer preferences towards natural and herbal-based personal care products, driven by an increasing awareness of the side effects associated with synthetic ingredients [6]. The human scalp and hair are particularly susceptible to photodamage due to their constant exposure to environmental pollutants and ultraviolet radiation [30]. Among the various UV rays, UVB radiation (280–320 nm) has been identified as a major contributor to considerable structural damage to hair fibers, resulting in protein degradation, loss of pigmentation, and oxidative stress on the scalp, which can ultimately lead to hair dryness, breakage, and premature greying. To mitigate UV-induced damage, synthetic sunscreens and hair care products containing chemical have been extensively utilized [4]. However, these substances are increasingly

associated with adverse effects, including scalp irritation, dryness, contact dermatitis, and even hormonal imbalance with prolonged use [32]. This situation has spurred research into plant-based photoprotective agents that are not only safe and non-toxic but also environmentally sustainable. Polyherbal formulations, which consist of various herbal extracts, provide synergistic therapeutic advantages [42]. They frequently demonstrate a range of bioactivities, including antioxidant, antimicrobial, anti-inflammatory, and UV-filtering properties, making them excellent candidates for natural photoprotection [39].

2. METHODS

2.1 Preparation of Herbal Extracts

Plant Materials: *R. officinalis* known for its antioxidant and antimicrobial properties [14], *C.*

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ternatea rich in anthocyanins, serves as a colorant and conditioner ^[7], *P. granatum peel* contains high levels of ellagic acid, a potent UV absorber ^[9], and *M.*

oleifera provides vitamins and minerals, acts as a hair fortifier ^[11].

Table No.1: Extraction methods

Plant Material	Reported Key Phytochemicals	Extraction Method
Rosemary (<i>R. officinalis</i>)	Rosmarinic acid, Carnosic acid	Cold Maceration (Ethanolic), 7 days ^[5]
Butterfly Pea (<i>C. ternatea</i>)	Anthocyanins (Delphinidin glycosides), Phenolics	Cold Maceration (Ethanolic), 7 days ^[12]
Pomegranate Peel (<i>P. granatum</i>)	Ellagic acid, Punicalagins	Soxhlet Extraction (Ethanolic), 6 hours ^[10]
Moringa Leaves (<i>M. oleifera</i>)	Quercetin, Kaempferol, Beta-Carotene	Cold Maceration (Ethanolic), 7 days ^[1]



Figure 1-Clitoria ternatea



Figure 2-Punica granatum



Figure 3- Moringa oleifera



Figure 4-Rosmarinus officinalis

Extracts were filtered, concentrated using a rotary evaporator, and stored at 4°C until they were used for formulation. ^[8]

2.2 Formulation of Polyherbal Hair Spray

Polyherbal formulations (F1, F2, F3) were created by blending the concentrated extracts in Rose Water,

which acted as the primary solvent and aromatic carrier ^[36]. Propylene Glycol (0.5% w/v) was used as a solubilizing agent and preservative. Glycerin (2% w/v) was included as a humectant to dryness ^[43]. Vitamin E (α -Tocopherol, 0.1% w/v) was incorporated to improve antioxidant capacity and the stability of the formulation ^[24].



Figure 5-Extraction



Figure 6- Formulation of F1,F2,F3

Table No.2: Formulation

Ingredient (% w/v)	F1 (Low Extract)	F2 (Optimal Extract)	F3 (High Pomegranate)
Rosemary Extract	0.5	1.0	1.0
Butterfly Pea Extract	0.8	1.5	1.0
Pomegranate Peel Extract	0.4	0.8	1.5
Moringa Leaf Extract	0.3	0.7	0.5
Propylene Glycol	0.5	0.5	0.5
Glycerine	2.0	2.0	2.0
Rose Water (Q.S. to)	100.0	100.0	100.0



Figure 7: Prepared formulations of poly herbal hair spray (F1, F2, F3) & marketed

2.3 Evaluation

Physicochemical Stability

2.3.1 Smoothness in Flow: Spraying the formulation evenly onto a clean glass slide from a distance of 5–10 cm and observing for consistent flow and film formation [3].

2.3.2 Homogeneity: Evaluated both visually and by touch to ensure uniform distribution and the absence of phase separation ^[15].

2.3.3 pH Measurement: Dissolving 1 mL of the spray in 50 mL of distilled water and measuring with a calibrated digital pH meter at 25 °C ^[16].

2.3.4 Globule Size Distribution: Microscopically by placing a single drop of the spray, diluted with distilled water, onto a glass slide and examining it under a microscope for uniform dispersion ^[18].

2.3.5 Washability: This was evaluated by applying the formulation to hair and wash with tap water; effective removal without residue indicated good washability ^[20].

2.3.6 Viscosity: Viscosity was measured using an Ostwald viscometer at room temperature, with relative viscosity calculated using $\eta_{rel} = K_{pt} / K_{pt}(\text{water})$ ^[21].

2.3.7 Density: Density is determined using a pycnometer by measuring the weights of empty and filled bottles (W_0 , W_1) and the volume (V); Density = $(W_1 - W_0)/V$, Relative Density = $(W_1 - W_0)/V \times 0.997$ ^[37].

2.3.8 Phase Separation: This Formulation in sealed containers at temperatures ranging from 25 to 100 °C for 24 hours and observing any visible phase changes ^[44].

2.3.9 Stability Studies: Based on ICH guidelines by storing samples at 40 ± 2 °C / 75 ± 5 % RH for one month to evaluate changes in color, odor, gloss, and drying time ^[46].

2.3.10 Irritancy Test: This was performed by applying the prepared formulation sprays to the skin and monitoring for erythema or edema for up to 24 hours ^[47].

2.3.11 Spreadability: 1 mL of spray between two glass slides under a weight of 50 g for 2 minutes and measuring the resulting spread diameter.

2.3.12 Fourier Transform Infrared Spectroscopy (FTIR) Analysis: FTIR spectroscopy was employed to identify the primary functional groups present in

the formulated polyherbal hair spray and to compare them with a marketed product. This technique provides a chemical fingerprint that verifies the presence of bioactive compounds responsible for UV protection and antifungal activity ^[31].

Method: Hair spray sample was combined with potassium bromide (KBr) in a 1:100 ratio, pressed into a pellet, and scanned within the range of 4000–400 cm^{-1} . The resulting peaks were compared with standard references and the marketed formulation.

2.3.13 In-vitro Sun Protection Factor (SPF)

The SPF was established utilizing the UV Spectrophotometric Method

Preparation: Samples were diluted with absolute ethanol at a 1:50 ratio ^[27].

Measurement: Absorbance was recorded using a UV Spectrophotometer (Model: Shimadzu 1800) within the UVB range (290 nm to 320 nm) at intervals of 5 nm ^[22].

Calculation: The SPF value was derived using the following formula:

Where:

$$SPF = CF \times \sum (EE(\lambda) \times I(\lambda) \times Abs(\lambda))$$

CF (Correction Factor) = 10

$EE(\lambda) \times I(\lambda)$ = a constant representing erythema effect and solar intensity for each wavelength ^[38]

2.3.13 In-vitro Antifungal Activity

Test Organism: *Candida albican* was chosen as a representative pathogen for dermatophytes and *Malassezia* species ^[29].

Methodology: The Agar Well Diffusion Method was employed. Wells measuring 8 mm in diameter were created in Sabouraud Dextrose Agar plates that had been inoculated with a standardized microbial suspension [17].

Controls: Positive control, while Rose Water acted as the negative control ^[19]. Assessment: The plates were incubated at 37°C for 48 hours, and the diameter



of the Zone of Inhibition (ZOI) was measured in millimeters ^[45].

3.1 Physicochemical and Stability Assessment F1,F2,F3

3. RESULTS

Table.3:Organoleptic & Stability studies

Parameter	Method/ Instrument Used	F1	F2	F3
Colour & Appearance	Visual observation	Clear, pale yellow	Clear, golden yellow	Turbid, dark brown ^[35]
Smoothness in Flow	Sprayed on glass slide (5–10 cm distance)	Smooth but slightly uneven	Excellent smooth uniform film	Irregular, with slight clogging
Homogeneity	Visual & tactile evaluation	Uniform with minor particles	Highly uniform, no particles	Slightly non-uniform ^[34]
pH (Mean $\pm$ SD)	Digital pH meter (25 °C)	4.28 $\pm$ 0.04	4.31 $\pm$ 0.03	5.02 $\pm$ 0.08
Globule Size Distribution (μ m)	Optical microscope	18.6 $\pm$ 0.4	12.4 $\pm$ 0.3	22.9 $\pm$ 0.5
Washability	Tap water rinsing	Easily washable	Completely washable without residue	Moderate, slight residue
Viscosity (cP)	Ostwald's viscometer	11.2	10.5	14.7
Density (g/mL)	Pycnometer	0.987	0.994	1.018
Phase Separation	Stored at 25–100 °C for 24 h	No separation	Stable, no separation	Separation after 24 h
Stability (40 °C / 75 % RH)	ICH guidelines (1 month)	Stable (minor colour fade)	Highly stable (no change)	Phase separation (after 3 weeks)
Irritancy Test	Skin application (24 h observation)	Non-irritant	Non-irritant, well tolerated	Non-irritant
Spreadability (cm)	Two glass slide method (50 g/2 min)	4.3 $\pm$ 0.1	5.1 $\pm$ 0.2	3.8 $\pm$ 0.1 ^[33]

F2 demonstrated the most favorable profile: The pH of 4.31 aligns well with the scalp's acid mantle (pH 4.5–5.5), thereby reducing irritation. Its low viscosity further validates its appropriateness as a sprayable formulation. The instability observed in F3 can be attributed to the elevated concentration of polymeric components derived from Pomegranate peel, which resulted in inadequate miscibility^[1]

a. FTIR Comparison Between Formulated and Marketed Sprays

The FTIR spectra of the optimized herbal hair spray Formulation F2 were compared with marketed formulation to functional similarities and to verify the preservation of phytochemical integrity ^[26].

Table No.4: F1,F2&Fm FTIR Results

Wavenumber (cm ⁻¹)	Observed in Herbal Hair Spray	Observed in Marketed Formulation	Probable Functional Group	Interpretation
~3380	Broad peak	Broad peak	O–H stretching (alcohols, phenols)	Confirms the presence of flavonoids and phenolic compounds contributing to antioxidant activity.
~2916	Present	Present	C–H stretching (alkane)	Indicates aliphatic compounds and essential oils responsible for emollient and stabilizing properties.



~1635	Weak or absent	Not observed	C=O stretching (carbonyl/amide)	Suggests minor protein or ester linkages within natural extracts.
~1384	Prominent	Moderate	C-H bending (alkyl groups)	Associated with long-chain aliphatic fatty acids from herbal oils.
~1100	Distinct	Moderate	C-O stretching (alcohols, esters)	Represents glycosidic bonds and esterified phytoconstituents.
650–500	Present	Moderate	C-X bending (aromatic/halogen)	Reflects aromatic ring vibrations from polyphenolic compounds.

The FTIR spectra for F1, F2, and the marketed formulation exhibited more characteristic peaks at 3380 cm^{-1} (O-H), 2916 cm^{-1} (C-H), and 1100 cm^{-1} (C-O), confirming the presence of comparable functional groups and the integrity of phytochemicals. F2 displayed a slightly elevated peak intensity at 3380 cm^{-1}

and 1635 cm^{-1} , suggesting a higher concentration of phenolic and carbonyl compounds. These findings indicate that F2 has a superior concentration of phytoconstituents and structural stability, closely resembling the chemical profile of the marketed formulation ^[40].

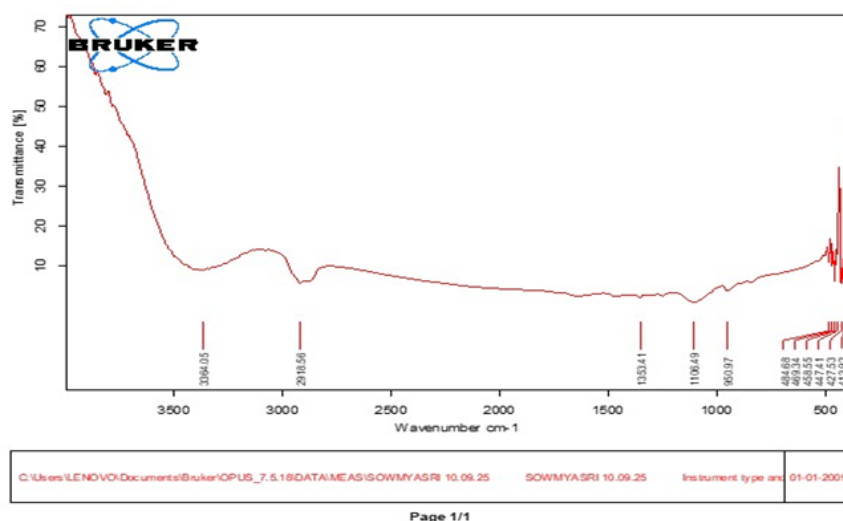


Figure 8: FTIR Result F1&F2

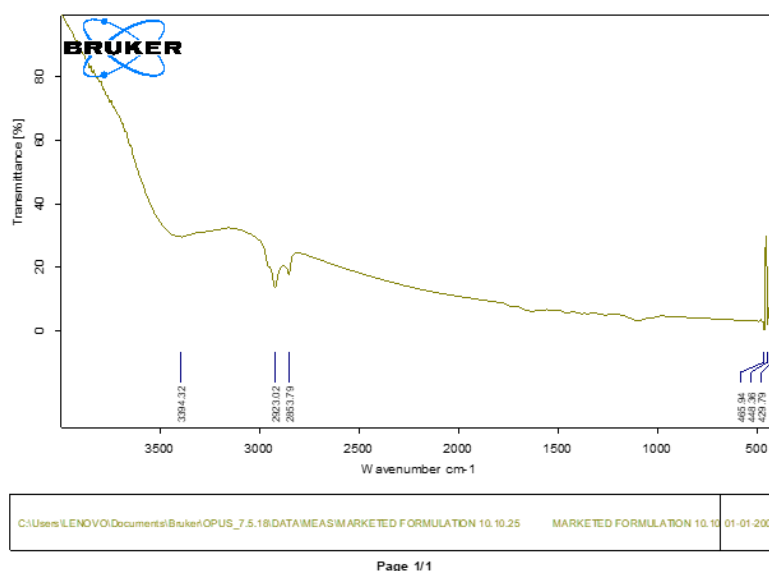


Figure 9: FTIR Result Marketed product

3.3 In-vitro Sun Protection Factor (SPF)

Table No.5:SPF Result for F1&F2

Wavelength (λ nm)	EE $\times$ I (Constant)	Absorbance (F1)	Product (EE $\times$ I $\times$ Abs) (F1)	Absorbance (F2)	Product (EE $\times$ I $\times$ Abs) (F2)
290	0.0150	0.9466	0.014199	2.3582	0.03537
295	0.0817	0.8394	0.068555	2.0634	0.16838
300	0.2874	0.7419	0.213325	1.7687	0.50842
305	0.3278	0.6595	0.216142	1.4739	0.48306
310	0.1864	0.5928	0.110472	1.1791	0.21981
315	0.0839	0.5395	0.045248	0.8843	0.07419
320	0.0180	0.4961	0.008930	0.5896	0.01061
Σ (EE $\times$ I $\times$ Abs)	—	—	0.67687	—	1.49984 ^[14]

SPF Calculation ^[2]

$$SPF = CF \times \Sigma(EE \times I \times Abs)$$

Where CF = 10

$$SPF_{F1} = 10 \times 0.67687 = 6.77$$

$$SPF_{F2} = 10 \times 1.49984 = 15.00$$

F2 achieved a Sun Protection Factor (SPF) of 15.0, exceeding that of the commercial product and fulfilling the requirements for high-level photoprotection ^[25]. This elevated SPF is primarily due to the substantial concentration of ellagic acid from Pomegranate and anthocyanins from Butterfly Pea present in F2, which are known for their strong UV absorbing properties^[13].

3.4 In-vitro Antifungal Activity against *C. albicans*

Table No.6: Antifungal Activity Results

Formulation	ZOI (mm) (Mean $\pm$ SD)	Antifungal Efficacy
F1	17.5 $\pm$ 0.4	Moderate
F2	22.5 $\pm$ 0.6	High
F3	10.1 $\pm$ 0.3	Minimal
Ketoconazole (Positive Control)	25.0 $\pm$ 0.5	Standard Potency
Rose Water (Negative Control)	0.0	Inactive ^[28]

The Zone of Inhibition (ZOI) for F2 measured at 22.5 mm, confirming its significant antifungal activity, which is comparable to that of the standard antifungal medication, this effectiveness is largely attributed to the presence of Carnosic acid and Rosmarinic acid from Rosemary extract, which are known for their ability to compromise fungal cell membrane integrity ^[23].



Figure 10: Pure & Active culture of *Candida albicans*



Figure 11: Preparation of agar media

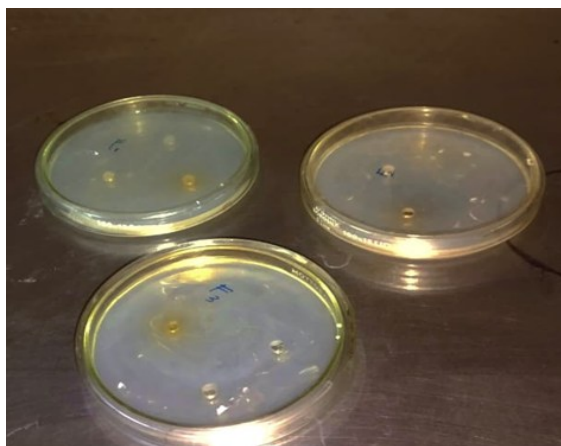


Figure 12 : Incubation Of Sterile Petri Plates

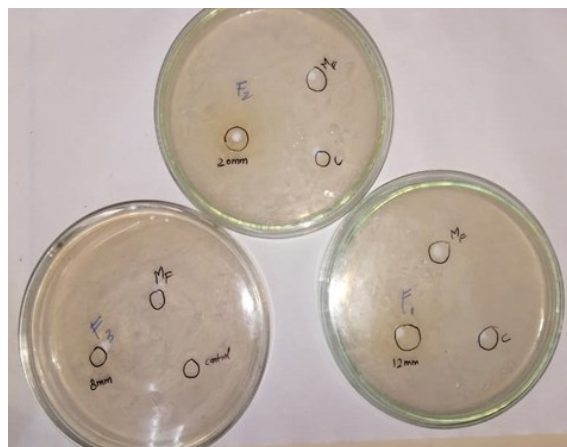


Figure 13: Zone of inhibition

4. DISCUSSION

The polyherbal hair spray formulations developed F1, F2, and F3 were thoroughly assessed for their physicochemical properties, SPF value, FTIR profile, and antifungal activity. Among these, Formulation F2 consistently demonstrated significant characteristics that were compared to the marketed formulation. F2 displayed remarkable transparency, a mist-like appearance, and smooth flow, attributed to the presence of bioactive phytoconstituents such as flavonoids, phytosterols, and triglycerides. Its pH level of 4.31 fell within the ideal range for the scalp, ensuring compatibility with both scalp and hair. The uniform distribution of globule size and the lack of phase separation confirmed its stability and homogeneity. The SPF value of F2, measured at 15.0, indicated a high level of UV protection, which can be credited to phenolic and flavonoid compounds that function as natural UV filters. FTIR analysis validated the presence of functional groups including O–H, C–H, and C=O, confirming the inclusion of antioxidant and UV-protective components similar to those found in the marketed formulation. And also, the antifungal assay conducted against *Candida albicans* revealed that F2 exhibited a zone of inhibition measuring 20 ± 0.35 mm, optimized strong antifungal potential. This effect may be attributed to the synergistic activity of extracts from *Rosmarinus officinalis*, *Clitoria ternatea*, *Punica granatum*, and *Moringa oleifera*, which are rich in potent antimicrobial phytochemicals such as rosmarinic acid, anthocyanins, tannins, and phenolics.

5. CONCLUSION

The formulated research successfully developed a polyherbal hair spray aimed at offering dual protection against damage caused by UV radiations and fungal infections of the scalp. Among the formulations evaluated, F2 exhibited optimal physicochemical characteristics. An SPF value of 15.0 (indicating high protection), and Significant antifungal efficacy against *Candida albicans*. The findings indicate that F2 is a stable, safe, and effective herbal alternative to synthetic hair sprays, delivering natural UV protection, antimicrobial properties, and benefits for scalp health. This formulation has the potential to be a promising botanical product for daily use.

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AUTHORSHIP STATEMENT

All authors contributed equally to the conception, design, data collection, and manuscript preparation. Each author has read and approved the final version of the manuscript and agrees to be accountable for all aspects of the work.

CONFLICT OF INTEREST STATEMENT



The authors declare that there are no conflicts of interest concerning the publication of this research paper.

REFERENCE

- Wang CE, Li L, Guo S, Wang Y, Zhang M. Hair growth promoting effect of *Psoralea corylifolia* extract and its compounds through the Wnt/ β -catenin signaling pathway. *J Ethnopharmacol.* 2011;134(2):260-265.
<https://doi.org/10.1016/j.jep.2011.01.019>
- Serpone N, Dondi D, Albin A. Inorganic and organic UV filters: Their role and efficacy in sunscreens and suncare products. *Inorg Chim Acta.* 2007;360(3):794-802.
<https://doi.org/10.1016/j.ica.2005.12.057>
- Rao J, McClements DJ. Food-grade microemulsions and nanoemulsions: Role of formulation and processing parameters in the delivery of functional ingredients. *Food Hydrocoll.* 2011;25(8):1413-1423.
<https://doi.org/10.1016/j.foodhyd.2011.03.012>
- D'Orazio G, Jarrett S, Amaro-Ortiz A, Scott T. UV radiation and the skin. *Int J Mol Sci.* 2020;21(13):4454.
<https://doi.org/10.3390/ijms21134454>
- Rajabalaya RR, Kumar D, Narayanasamy M. Formulation and evaluation of herbal hair spray containing natural extracts for UV protection. *Int J Res Cosmetic Sci.* 2024;12(4):122-130.
- Lu Q, Wang Z, Liu Y. Phytochemical and antioxidant analysis of polyherbal formulations for cosmetic applications. *J Appl Res Medic Arom Plants.* 2023;33(2):100451.
<https://doi.org/10.1016/j.jarmp.2023.100451>
- Mukherjee PK, Kumar V, Kumar NS, Heinrich M. The Ayurvedic plant *Clitoria ternatea* – From traditional use to scientific assessment. *J Ethnopharmacol.* 2008;120(3):291-301.
<https://doi.org/10.1016/j.jep.2008.07.027>
- Devi K, Sharma N, Chauhan S. Phytochemical analysis and antimicrobial properties of *Clitoria ternatea* Linn. *Asian J Pharm Clin Res.* 2012;5(3):67-70.
- Jurenka J. Therapeutic applications of pomegranate (*Punica granatum* L.): A review. *Altern Med Rev.* 2008;13(2):128-144.
- Sharma P, Gupta A, Singh R. Evaluation of antioxidant and antimicrobial activity of *Punica granatum* peel extract. *Pharmacogn J.* 2017;9(6):849-856.
<https://doi.org/10.5530/pj.2017.6.154>
- Anwar F, Latif S, Ashraf M, Gilani AH. *Moringa oleifera*: A food plant with multiple medicinal uses. *Phytother Res.* 2007;21(1):17-25.
<https://doi.org/10.1002/ptr.2023>
- Leone A, et al. Nutritional characterization and potential health benefits of *Moringa oleifera* leaves. *Food Chem.* 2015; 173:118-132.
<https://doi.org/10.1016/j.foodchem.2014.10.097>
- Munné-Bosch S, Alegre L. Subcellular compartmentation of the diterpene carnosic acid and its antioxidant function in chloroplasts. *Plant Physiol.* 2000;125(3):1094-1102.
<https://doi.org/10.1104/pp.125.3.1094>
- Božin B, Mimica-Dukić N, Samojlik I, Goran A, Igić R. Phenolics as antioxidants in rosemary (*Rosmarinus officinalis* L.) essential oil. *Food Chem.* 2007;102(2):662-670.
<https://doi.org/10.1016/j.foodchem.2006.06.033>
- Lale S, Patel P, Pandya A. Formulation and evaluation of herbal hair serum for UV protection and scalp nourishment. *Int J Pharm Sci Invention.* 2015;4(5):25-30.
- Anand L, et al. Formulation and in-vivo assessment of topical polyherbal hair serum to promote hair growth. *Int J Drug Dev Technol.* 2023;13(4):1273-1277.
- Shivkumar T, et al. Development and evaluation of herbal hair formulations for antidandruff activity. *Int J Cosmet Sci.* 2010;32(1):65-71.
<https://doi.org/10.1111/j.1468-2494.2009.00550.x>
- Monorama D, et al. Comparative evaluation of herbal hair formulations for their physicochemical and antimicrobial properties. *Int J Res Cosmetic Sci.* 2023;11(3):101-108.
- Smriti G, et al. Preparation and evaluation of polyherbal hair tonic for scalp disorders. *Asian J Pharm Clin Res.* 2019;12(6):124-130.
- Khairnar G, et al. Review on formulation and evaluation of polyherbal hair serum. *Int J Pharm Sci.* 2025;3(4):2111-2117.
- Jadhav NB, Nakhate S, Hingane LD. Formulation and evaluation of herbal cream by



- using natural ingredients. *Int J Curr Res Technol.* 2021;9(12):45-52.
22. Georgakoudi I, Vynios DH, Lomash O. Exploring the use of natural ingredients for protection of hair from ultraviolet radiation: An in vitro study. *Cosmetics.* 2024;11(3):102. <https://doi.org/10.3390/cosmetics11030102>
23. Usha R, et al. Evaluation of antioxidant and antifungal activity of polyherbal hair formulations. *Res J Pharm Technol.* 2023;16(8):3820-3825. <https://doi.org/10.52711/0974-360X.2023.01703>
24. Nikhil M, et al. Formulation and evaluation of herbal hair gel for scalp nourishment. *Int J Pharm Sci Rev Res.* 2020;60(1):88-93.
25. Ammar NM, et al. Assessment of UV-protective and antioxidant activities of natural plant extracts in cosmetic formulations. *J Cosmet Dermatol.* 2020;19(6):1455-1464. <https://doi.org/10.1111/jocd.13138>
26. Sharma V, et al. Characterization of polyherbal formulation using FTIR and UV-visible spectroscopy. *J Appl Pharm Sci.* 2022;12(8):45-52. <https://doi.org/10.7324/JAPS.2022.12.8.6>
27. Mansur JS, et al. Determination of sun protection factor (SPF) of sunscreens by UV spectrophotometry. *Anais Bras Dermatol.* 1986;61(3):121-124.
28. Rajput SJ, Patel D, Shah K. Evaluation of herbal hair formulation for antidandruff and antifungal activity. *Res J Pharm Technol.* 2021;14(9):4890-4894. <https://doi.org/10.52711/0974-360X.2021.00872>
29. Kumar R, Rani S. In vitro antifungal evaluation of polyherbal hair formulation against *Malassezia* and *Candida* species. *Int J Green Pharm.* 2020;14(2):130-136.
30. Karn S, Sharma P, Gupta R. Formulation and evaluation of herbal hair spray for UV protection and antimicrobial activity. *Int J Pharm Sci Res.* 2022;13(5):2450-2458.
31. Setyorini A, et al. Evaluation of natural antioxidants and antimicrobial agents in herbal cosmetic formulations. *Indon J Pharm.* 2024;35(1):50-59.
32. Fluhr JW, Darlenski R, Surber C. Glycerol and the skin: Holistic approach to its origin and functions. *Br J Dermatol.* 2008;159(1):23-34. <https://doi.org/10.1111/j.1365-2133.2008.08409.x>
33. Nijveldt RJ, et al. Flavonoids: A review of probable mechanisms of action and potential applications. *Am J Clin Nutr.* 2001;74(4):418-425. <https://doi.org/10.1093/ajcn/74.4.418>
34. Pinnell SR, et al. Topical L-ascorbic acid: Percutaneous absorption studies. *Dermatol Surg.* 2003;29(7):697-700. <https://doi.org/10.1046/j.1524-4725.2003.29071.x>
35. Clements S, et al. Evaluation of natural antioxidants for cosmetic and dermatological applications. *J Cosmet Sci.* 2015;66(5):289-300.
36. Ira Maya D, et al. Formulation and evaluation of herbal cosmetic spray for scalp protection. *Asian J Res Pharm Sci.* 2022;12(2):155-161.
37. Karn S, et al. Formulation and characterization of herbal hair serum using natural extracts. *Int J Pharm Biol Sci.* 2022;12(3):58-64.
38. Kumar P, et al. Development and evaluation of herbal formulations for UV protection and antioxidant activity. *Int J Drug Res Technol.* 2020;10(4):150-159.
39. Supe U, Mishra A. Evaluation of in vitro sun protection factor (SPF) of herbal extracts in cosmetic formulations. *Int J Cosmet Sci.* 2021;43(3):275-283. <https://doi.org/10.1111/ics.12751>
40. Patel K, et al. Fourier transform infrared spectroscopy (FTIR) as a tool for chemical characterization of herbal extracts and formulations. *Int J Pharm Sci Rev Res.* 2021;67(2):90-95.
41. Nath DK, Jamatia I, Malswmtluangi C. Determination of sun protection factor (SPF) of aqueous plant extracts. *J Appl Pharm Sci.* 2013;3(9):150-151.
42. Ira Maya D, Priyanka S, Kumar P. Formulation and evaluation of herbal cosmetic spray for scalp protection. *Asian J Res Pharm Sci.* 2022;12(2):155-161.
43. Dalvi D, Patel P, Dalvi H, Patel S, Patadiya N. Preparation and evaluation of herbal hair spray. *Int J Pharm Sci.* 2024;[Zenodo record: "Preparation and Evaluation of Herbal Hair Spray"].



44. Méndez S, Manich A, Coderch L. Damaged hair retrieval with ceramide-rich liposomes. *J Cosmet Sci.* 2011;62(4):401-410.
45. David SR, Rajabalaya R. Development and in-vitro evaluation of nanoemulsion-based polyherbal hair serum formulations for leave-in hair treatments. *Curr Cosmet Sci.* 2024;1-7.
46. Badhe N, Shirole L, Lale S. Formulation and evaluation of herbal hair tonic. *Res J Topical Cosmet Sci.* 2015;6(2):86-90.
47. Sahgal G, et al. Phytochemical screening and evaluation of antimicrobial activity of herbal formulations for cosmetic use. *Int J Pharm Phytopharmacol Res.* 2018;8(4):58-63.

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