

Development and Evaluation of Herbal Oil-Loaded Hair Powder for Anti-Dandruff and Scalp Conditioning

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Abstract- Dandruff is a common scalp disorder associated with fungal infection, irritation, itching, and flaking of the scalp. Conventional hair oils used for conditioning often increase scalp greasiness and may worsen dandruff conditions by providing a lipid-rich environment for *Malassezia* fungi. Therefore, the development of an herbal oil-loaded hair powder using a solid-state adsorption technique offers a non-greasy, effective alternative. In this study, coconut oil and clove oil were successfully converted into a free-flowing powder utilizing natural adsorbents such as bentonite, magnesium carbonate, talc, and corn starch. The formulation was further enriched with herbal powders including *Azadirachta indica* (Neem), *Hibiscus rosa-sinensis*, *Emblica officinalis* (Amla), and *Trigonella foenum-graecum* (Fenugreek) for their synergistic antifungal, antioxidant, and conditioning properties. The prepared formulations were evaluated for various parameters including organoleptic properties, pH, angle of repose, bulk density, stability, and antifungal activity. The prepared hair powder showed excellent flow properties, acceptable skin-compatible pH, satisfactory stability, and effective anti-dandruff activity. The study concludes that the herbal oil-loaded powder is a promising, safe, and cost-effective topical preparation for the management of dandruff and scalp conditioning.

Keywords: Herbal hair powder, adsorption technique, anti-dandruff, conditioning activity, herbal formulation.

I. INTRODUCTION

Hair is considered a vital component of human identity, and the scalp serves as a protective barrier for the cranium. However, the scalp is frequently susceptible to dermatological conditions, the most prevalent being Dandruff (Pityriasis capitis). Dandruff is a chronic scalp disorder characterized by excessive shedding of dead skin cells, accompanied by itching and redness, affecting nearly 50% of the adult population globally. The primary causative agent is the lipophilic yeast-like fungus, *Malassezia furfur*, which thrives in sebum-rich environments and breaks down lipids into pro-inflammatory fatty acids.

While conventional treatments like hair oils provide nourishment, they often leave the scalp excessively greasy, which can trap dirt and exacerbate fungal proliferation. Synthetic anti-dandruff shampoos containing chemicals like Zinc Pyrithione and Ketoconazole are effective but may cause side

effects such as hair dryness or scalp irritation with long-term use.

Topical dosage forms utilizing the adsorption technique have gained significant importance in recent years as a novel vehicle for drug delivery. Adsorption bridges the gap between the therapeutic efficacy of essential oils and the aesthetic requirement of non-greasy applications by transforming liquid lipid phases into solid-state delivery systems.

The present study focuses on the formulation and evaluation of an herbal oil-loaded hair powder to provide effective anti-dandruff action. The formulation contains coconut oil, clove oil, and standardized botanical powders like neem and amla, which together enhance the antifungal and scalp-conditioning effects while the porous adsorbent matrix naturally sequesters excess sebum.

II. MATERIAL AND METHODOLOGY

Active Ingredients Used in Formulation

Neem: The biological source is the standardized herbal powder of *Azadirachta indica*. Its chemical constituents include bitter triterpenoids, azadirachtin, and nimbin. It functions as an anti-dandruff and antibacterial agent. It works to relieve itching and treats the root causes of scalp flaking by exerting powerful anti-inflammatory, antibacterial, and secondary antifungal effects against scalp microbes.



Figure 1: Standardized Neem Powder Extract

Clove Oil: The biological source is the essential oil of *Syzygium aromaticum*. Its primary chemical constituent is eugenol, a volatile phenolic compound. It acts as an active antifungal and soothing agent, providing relief from fungal infections and scalp pruritus. Its mechanism of action disrupts the cell membranes of lipophilic fungi like *Malassezia furfur* and stimulates microcirculation around hair follicles.



Figure 2: Clove Oil Preparation

Bentonite: This functions as the primary porous adsorbent. It acts as a molecular sponge due to its layered crystalline structure and high cation-exchange capacity; it safely entraps liquid oils while

drawing out impurities, detoxifying, and cleansing the scalp.

Table 1: Ingredients Collection & Category

Sr.No	Ingredients	Collection	Category
1.	Coconut Oil	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Conditioning agent
2.	Clove Oil	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Antifungal agent
3.	Bentonite	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Primary adsorbent
4.	Magnesium Carbonate	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Oil adsorbent
5.	Talc	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Glidant
6.	Corn Starch	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Moisture absorbent
7.	Neem Powder	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Anti-dandruff agent
8.	Hibiscus Powder	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Conditioner
9.	Amla Powder	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Antioxidant
10.	Fenugreek Powder	L.S.D.P. College of Pharmacy, Mandavgan Pharata	Moisturizer

Solid-State Adsorption Technique (Liquid-to-Solid Transformation)

All herbal ingredients (Neem, Hibiscus, Amla, Fenugreek) are dried to a constant weight and sieved through a 60 or 80 mesh to ensure uniform particle size. The adsorbent base containing Bentonite, Magnesium Carbonate, Talc, and Corn Starch is weighed accurately and blended using geometric dilution. Coconut oil and Clove oil are premixed to ensure a homogenous lipid phase.

The oil mixture is then added dropwise to the adsorbent base under continuous trituration in a mortar and pestle. This is continued until the oil is completely internalized, resulting in a dry, free-flowing powder. The processed herbal powders are

incorporated into the oil-loaded base, mixed thoroughly, and passed through a final sieve to remove clumps. The final product is stored in an airtight, UV-protected container.

Table 2: Formulation Variations (F1, F2, F3)

Sr.no.	Ingredients	F1	F2	F3
1.	Coconut Oil	6 ml	8 ml	10 ml
2.	Clove Oil	1 ml	2 ml	3 ml
3.	Bentonite	22 g	20 g	18 g
4.	Magnesium Carbonate	15 g	15 g	15 g
5.	Talc	15 g	15 g	15 g
6.	Corn Starch	10 g	10 g	10 g
7.	Neem Powder	10 g	10 g	10 g
8.	Hibiscus Powder	8 g	8 g	8 g
9.	Amla Powder	7 g	7 g	7 g
10.	Fenugreek Powder	5 g	5 g	5 g

Evaluation of Herbal Hair Powder

Evaluation tests for the Hair Powder are carried out to check the quality, physical properties, and effectiveness of the prepared formulation. The physical appearance of the prepared powder is observed visually for color, odor, and texture. A good formulation should be a free-flowing solid powder. The pH of a 1% suspension of the formulation is measured and should be suitable for skin application (around 4.5-6.0) to avoid epidermal irritation.

Micromeritic flowability is measured using the Angle of Repose, calculated mathematically.

Other key metrics include Bulk Density, Tapped Density, Carr's Index, and Hausner Ratio. This ensures the formulation meets pharmaceutical standards for "Good" to "Excellent" flow. The formulation is also subjected to accelerated stability testing (varying temperature and humidity) and observed for changes in color, odor, and moisture content over a 3-month period. Finally, antifungal activity is evaluated using the Zone of Inhibition (ZOI) against *Malassezia* species to confirm the formulation retains its therapeutic effect.

III. RESULTS

Table 3: Result of Herbal Hair Powder

Sr.no.	Parameter	Observation / Result (Optimal Formulation)
1.	Organoleptic character	
	Colour	Light Brown
	Odour	Characteristic Herbal (Clove-dominant)
	Texture / Physical Form	Fine, Smooth / Free-flowing Solid Powder
2.	pH (1% Suspension)	Neutral (Approx. 6.2)
3.	Angle of Repose	28.5°
4.	Bulk Density	0.45 g/ml
5.	Tapped Density	0.53 g/ml
6.	Carr's Index	15.90%
7.	Hausner Ratio	1.18
8.	Stability Study	Physically and Chemically Stable
9.	Anti-fungal Activity	Effective against <i>Malassezia</i> species

IV. CONCLUSION

The present study successfully demonstrated the development, formulation, and evaluation of a novel herbal oil-loaded hair powder utilizing an advanced solid-state adsorption technique. By effectively transitioning lipophilic liquid phases—specifically nourishing coconut oil and therapeutic clove oil—into a free-flowing solid matrix using natural adsorbents like bentonite and magnesium carbonate, the clinical challenge of topical oil-induced greasiness was overcome.

The standardized botanical powders (*Azadirachta indica*, *Hibiscus rosa-sinensis*, *Emblca officinalis*, and *Trigonella foenum-graecum*) were effectively incorporated to enhance the anti-dandruff and conditioning activity. The optimized formulation exhibited excellent micromeritic flow properties, a neutral skin-compatible pH, and robust in-vitro antifungal efficacy against dandruff-causing *Malassezia* strains. Compared to conventional

synthetic anti-dandruff preparations or messy liquid oils, this herbal formulation offers a non-greasy, safe, cost-effective, and natural therapeutic alternative with good patient acceptability.

Therefore, this oil-loaded herbal hair powder can be considered a highly promising "green cosmeceutical" for the holistic management of scalp and hair health.

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Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this project work.

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