Preparation and Evaluation of Hair Growth and Anti-Dandruff Shampoo

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***Abstract*—The shift toward "green" cosmetics has intensified the search for botanical alternatives to synthetic surfactants like SLS. This research focuses on the formulation and pharmaceutical evaluation of a poly-herbal shampoo utilizing Karanja oil (*Pongamia pinnata*) and Soap Nut (*Sapindus mukorossi*). Karanja oil, rich in furanoflavonoids (karanjin and pongamol), provides targeted antifungal activity against *Malassezia furfur*. Reetha extract provides natural triterpenoid saponins for gentle cleansing. Results indicated a stable formulation with a pH of 6.5, viscosity of 2997 cP, and a stable foam volume of 50 ml, validating the bridge between traditional Ayurvedic knowledge and modern pharmaceutical standards.**

I. INTRODUCTION

The modern cosmetic industry is undergoing a paradigm shift towards sustainable and "green" formulations. Consumers are increasingly wary of synthetic chemicals, particularly sulfates and parabens, due to rising scalp sensitivities and environmental concerns. Traditional synthetic shampoos often rely on Sodium Lauryl Sulfate (SLS), which, while effective at removing dirt, often disrupts the scalp's natural acid mantle and lipid barrier.

1.1. Problem Statement

Dandruff, or seborrheic dermatitis, affects nearly 50% of the adult population. It is primarily caused by the over-proliferation of *Malassezia furfur*. Most commercial anti-dandruff solutions use Zinc Pyrithione or Ketoconazole, which can lead to hair brittleness and scalp dryness. There is a critical need for a formulation that combines antifungal efficacy with nourishing hair-growth properties using biodegradable ingredients.

1.2. Rationale for Karanja and Reetha

Karanja oil is a cornerstone of Ayurvedic medicine. Its pharmacological efficacy is attributed to furanoflavonoids. Unlike synthetic oils, Karanja oil offers a dual benefit: it inhibits fungal growth while providing essential fatty acids that fortify the hair cuticle. Soap Nut (Reetha) serves as a surfactant alternative. The triterpenoid saponins in Reetha lower surface tension without aggressive stripping, maintaining the scalp's physiological balance.

II. BOTANICAL & CHEMICAL PROFILES

2.1. Pongamia pinnata (Karanja)

The oil extracted from Karanja seeds contains karanjin and pongamol. Research indicates these compounds interfere with the cell membrane integrity of lipophilic yeasts. Furthermore, the oil provides a natural UV shield, mitigating oxidative stress on the scalp.

2.2. Sapindus mukorossi (Soap Nut)

The fruit pericarp of *Sapindus mukorossi* contains up to 10-15% saponins. These glycosides consist of a hydrophilic sugar moiety and a hydrophobic aglycone (sapogenin). This structure allows for the emulsification of environmental pollutants and excess sebum.

2.3. Auxiliary Green Surfactants

- Decyl Glucoside: A non-ionic surfactant derived from coconut/corn. It is highly biodegradable and exceptionally mild on ocular mucosa.
- Cocamidopropyl Betaine (CAPB): An amphoteric surfactant that acts as a foam booster and reduces the irritation potential of the overall surfactant system.

2.4. Rheology and Stability Modifiers

Natural formulations often suffer from phase separation. Xanthan Gum, a polysaccharide produced by *Xanthomonas campestris*, is utilized to create a pseudoplastic flow, ensuring the Karanja oil remains uniformly suspended in the aqueous base.

III. LITERATURE REVIEW

The development of herbal shampoos has been documented extensively over the last decade. A summary of key research influencing this project is provided below:

Author & Year	Focus Area	Key Findings
Saha, S. (2010)	Sapindus mukorossi	Validated Reetha's cleansing efficiency vs. synthetic SLS.
Bhalodia (2011)	Antifungal activity	Karanja oil showed zone of inhibition against M. furfur.
Choudhary (2025)	Hair Cuticle	Furanoflavonoids provide structural reinforcement to hair keratin.
Schmid (2026)	Green Chemistry	Decyl Glucoside as a sustainable surfactant for sensitive skin.

IV. MATERIALS AND METHODS

4.1. List of Materials

All herbal extracts were procured from certified suppliers. Surfactants and preservatives were eco-certified grades suitable for natural cosmetics.

Ingredient	Function
Soap Nut Extract	Natural Saponin Surfactant
Karanja Oil	Antifungal Active
Decyl Glucoside	Mild Cleansing Agent
CAPB	Foam Booster/Conditioner
Xanthan Gum	Viscosity Modifier
PEG-7 Glyceryl Cocoate	Superfatting Agent/Solubilizer
Benzyl Alcohol & DHA	Broad-spectrum Preservative

4.2. Extraction of Reetha Saponins

100g of Soap Nut pericarp was boiled in 500ml of distilled water for 45 minutes to ensure maximum extraction of glycosides. The solution was cooled, filtered through a 0.22-micron filter to remove particulate matter, and concentrated to a specific gravity of 1.05.

V. EXPERIMENTAL PROCEDURE

5.1. Pre-formulation Studies

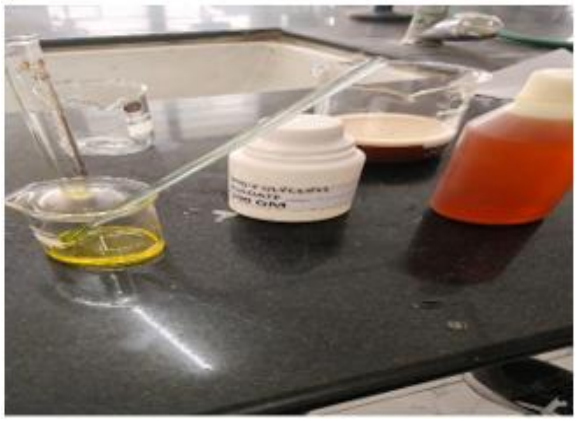
Before final compounding, the Karanja oil underwent organoleptic and solubility testing. It was found to be freely soluble in acetone but insoluble in water, necessitating the use of PEG-7 Glyceryl Cocoate as a solubilizing bridge.

5.2. Compounding Steps

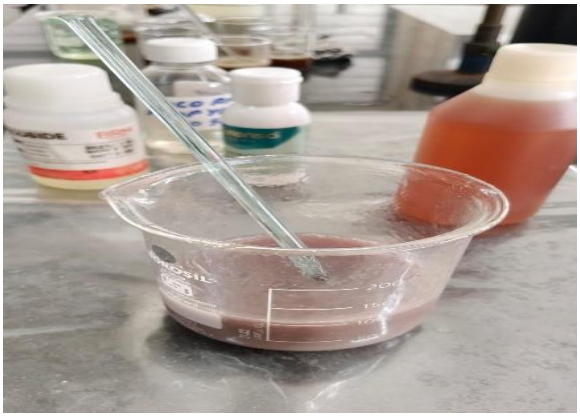
The formulation followed a cold-process emulsification technique to preserve the heat-sensitive bioactive compounds in Karanja oil.

1. Phase A (Aqueous Base): Xanthan gum (1g) was slurried in Glycerin (3ml) to prevent clumping. Distilled water (45ml) and Reetha extract (15ml) were added under constant stirring at 300 RPM.

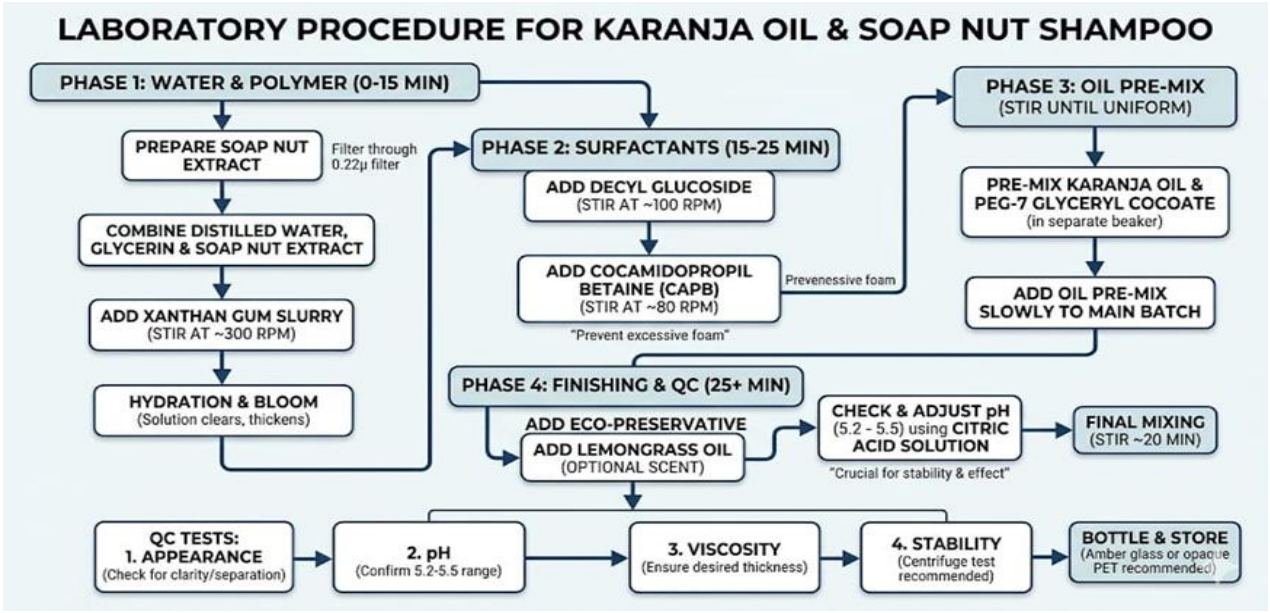
2. Phase B (Surfactant System): Decyl Glucoside (15ml) and CAPB (12ml) were introduced. Stirring speed was reduced to 80 RPM to minimize excessive foaming.



3. Phase C (Active Solubilization): Karanja oil (1.5ml) was pre-mixed with PEG-7 Glyceryl Cocoate (4ml). This mixture was slowly titrated into the main batch until a translucent amber appearance was achieved.



4. Phase D (Finishing): Citric acid (50% sol.) was added dropwise to adjust the pH. Finally, the preservative system and Lavender oil were added.



VI. EVALUATION PARAMETERS

Standardized pharmaceutical protocols were followed to ensure safety and efficacy.

6.1. Physicochemical Testing

- pH Determination: 1g of shampoo was dispersed in 10ml water. Measurement was performed using a calibrated digital pH meter.
- Viscosity: Measured using a Brookfield Viscometer (Spindle 4, 50 RPM, 25°C).

• Foam Stability: 50ml of a 1% solution was shaken in a graduated cylinder. Foam volume was recorded at 0 and 5 minutes.

6.2. Dermatological Safety

Skin Irritation Test: A patch test was conducted on a limited area of human skin. Observations were recorded over 24 hours for signs of erythema or edema.

6.3. Foam height

A 1% v/v shampoo solution was prepared using distilled water. About 50 ml of this solution was transferred into a graduated measuring cylinder and shaken vigorously for 10 cycles. The total volume of liquid and foam was recorded after 1 minute, and foam volume was calculated by subtracting the initial liquid volume. The foam volume was further measured at regular time intervals to assess foam stability

6.4. Viscosity Determination

10 g of shampoo was placed in a sample container. Spindle was immersed in the gel. Viscosity reading was taken at 25°C and rotation speed 50 rpm.

VII. RESULTS

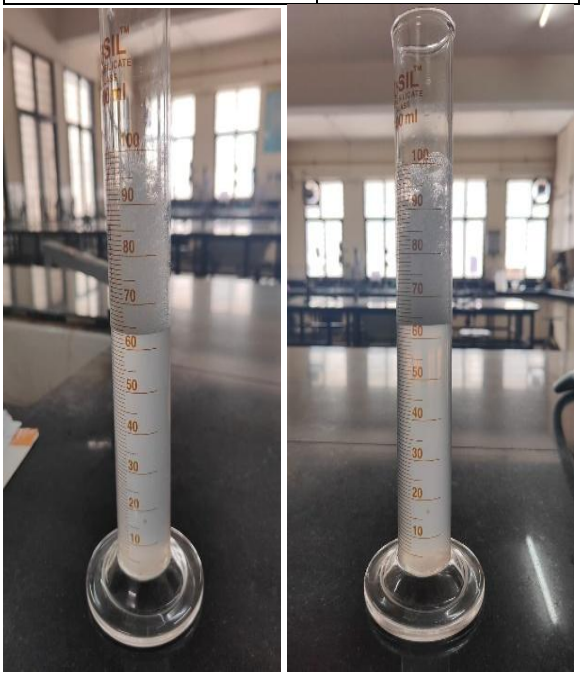
The formulated shampoo exhibited excellent physical characteristics and stability.

7.1. Pre-formulation Results

Parameter	Result
Colour	Brownish
Odour	Nutty/Pungent
Consistency	Oily and Viscous
pH (Extract)	5.5 – 6.3

7.1. Final Formulation Evaluation

Parameter	Observation
Appearance	Translucent Lavender
pH	6.5
Viscosity	2997 cP
Skin Irritation	None Observed
Initial Foam Height	90 ml
Final Foam Height (1 min)	80 ml



VIII. DATA ANALYSIS & VISUALIZATION

The following chart illustrates the comparison between initial and final foam heights, indicating high foam stability—a critical factor for consumer acceptance.

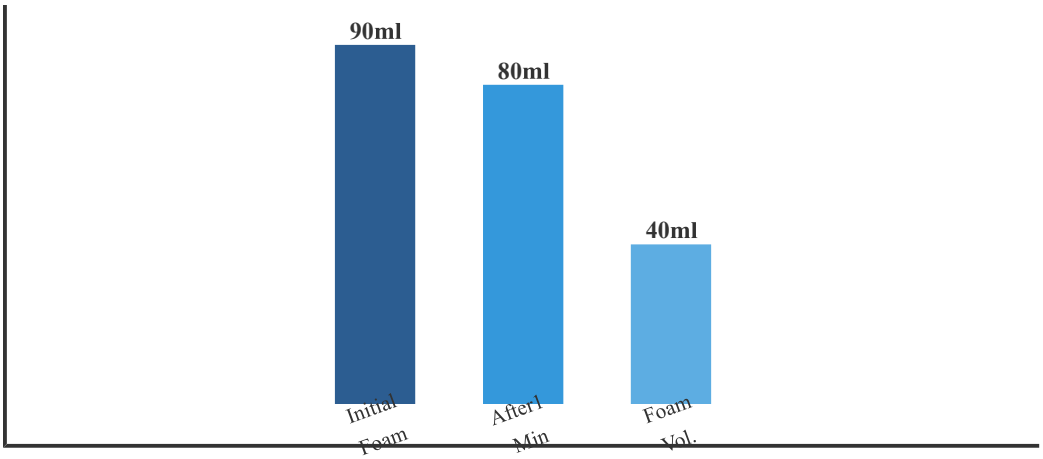


Figure 1: Foam Stability Performance Comparison

The viscosity of 2997 cP suggests an ideal pour ability, comparable to premium commercial grade shampoos. The pH of 6.5 is slightly higher than the ideal 5.5 but remains well within the safe physiological range for scalp application, preventing irritation.

IX. DISCUSSION

The primary challenge in this research was the integration of Karanja oil into an aqueous surfactant base without causing phase separation. Karanja oil is highly hydrophobic. By utilizing PEG-7 Glyceryl Cocoate as a superfatting agent, we successfully emulsified the oil. This not only stabilized the shampoo but also provided "re-lipidization" benefits, preventing the dryness typically associated with Reetha-based cleansers.

9.1. Antifungal Synergy

The synergy between Reetha saponins and Karanja furanoflavonoids provides a multi-pronged attack on dandruff. While Reetha cleanses the scalp of fungal food sources (excess sebum), Karanja oil actively inhibits the *Malassezia* species. This dual action is superior to monotherapy.

9.2. Environmental Impact

The use of Decyl Glucoside and Citric Acid aligns with "Green Chemistry" principles. The formulation is highly biodegradable, posing minimal risk to aquatic life upon disposal. The absence of SLS ensures that the product does not contribute to the bioaccumulation of toxic sulfates in the environment.

X. SUMMARY AND CONCLUSION

This project successfully formulated a polyherbal shampoo that meets the rigorous standards of modern pharmaceutical science. The integration of Karanja oil (active antifungal) and Soap Nut (natural surfactant) provides a viable alternative to synthetic anti-dandruff treatments.

Key findings include:

- Successful masking of Karanja oil's pungent odour with Lavender essential oil.
- Achievement of optimal viscosity (2997 cP) for consumer ease of use.
- Stability of the foam system, ensuring effective cleansing power.
- Maintenance of scalp health through pH regulation and the inclusion of superfatting agents.

In conclusion, the developed "green" shampoo is safe, effective, and environmentally sustainable. Future studies could involve long-term clinical trials to quantify hair growth rates over a 6-month period.

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