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Original Research Article

FORMULATION EVALUATION OF ANTIDANDRUFF HERBAL SHAMPOO

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ABSTRACT

Dandruff is a common scalp disorder associated with excessive flaking, itching, and irritation, primarily caused by fungal colonization and imbalance of scalp physiology. Conventional anti-dandruff shampoos containing synthetic antifungal agents are effective but may lead to adverse effects such as scalp dryness, irritation, and hair damage upon prolonged use. The present study focuses on the formulation development and evaluation of an herbal anti-dandruff shampoo using selected essential oils and herbal ingredients known for their antifungal and scalp-conditioning properties. Volatile oils were extracted by hydrodistillation and incorporated into an optimized shampoo base selected based on physical stability and foaming characteristics. The formulated test shampoo (TS) was evaluated for physicochemical properties including pH, detergency, wetting time, surface tension, viscosity profile, foam volume and stability, and storage stability. The performance of the test shampoo was compared with six commercially available marketed shampoos. The test formulation demonstrated superior detergency, acceptable wetting time, efficient surface tension reduction, and desirable non-Newtonian rheological behavior comparable to marketed products. Stability studies indicated no significant changes in appearance, odor, foam characteristics, surface tension, detergency, or viscosity over a six-month period. The findings suggest that the developed herbal anti-dandruff shampoo is effective, stable, and suitable for regular use, offering a safe and natural alternative to synthetic anti-dandruff formulations.

Keywords: Herbal anti-dandruff shampoo, Essential oils, Detergency, Surface tension, Viscosity, Stability studies, Hair care formulation.

INTRODUCTION

Dandruff is a common chronic scalp disorder characterized by excessive flaking of the scalp skin, often accompanied by itching and irritation. It affects a large proportion of the global population irrespective of age and gender and, although not life-threatening, can significantly impact an individual's quality of life and self-confidence (Ranganathan and Mukhopadhyay, 2010). The condition is primarily associated with the overgrowth of *Malassezia* species, increased sebaceous gland activity, disruption of the scalp barrier, and inflammatory responses. Conventional anti-dandruff shampoos commonly contain synthetic antifungal agents such as zinc pyrithione, ketoconazole, selenium sulfide, and coal tar (Honnavar *et al.*, 2021). While these agents are effective, their long-term use has been associated with adverse effects including scalp dryness, irritation, hair damage, and potential development of microbial resistance.

In recent years, there has been growing consumer preference for herbal and naturally derived cosmetic products due to their perceived safety, biocompatibility, and minimal side effects. Herbal anti-dandruff shampoos utilize plant-based ingredients possessing antifungal, anti-inflammatory, antioxidant, and cleansing properties, which can effectively manage dandruff while maintaining scalp and hair health. Formulation of an effective herbal anti-dandruff shampoo requires careful selection and optimization of natural surfactants, conditioning agents, and bioactive plant extracts to ensure adequate cleansing, foamability, stability, and consumer acceptability (Selvakumar *et al.,* 2012). Unlike synthetic formulations, herbal shampoos must be evaluated rigorously for physicochemical properties such as pH, viscosity, surface tension, solid content, foam stability, and cleansing efficiency, along with antimicrobial efficacy and stability studies (Vijayakumar *et al.*, 2006). Proper formulation development ensures that the herbal actives remain stable and effective throughout the product's shelf life.

Therefore, the present research focuses on the formulation development and evaluation of a herbal anti-dandruff shampoo using selected medicinal plant extracts with proven antifungal and scalp-soothing properties. The study aims to develop a safe, effective, and eco-friendly shampoo formulation that not only controls dandruff but also promotes overall scalp and hair health, offering a promising alternative to conventional synthetic anti-dandruff products.

MATERIALS AND METHODS

Materials

The materials used in the present study included plant-derived raw materials and standard cosmetic ingredients. Volatile oils such as cinnamon oil (*Cinnamomum zeylanicum*), kapur tulsi oil (*Ocimum kilimandscharicum*), eucalyptus oil (*Eucalyptus globulus*), and cajeput oil were obtained by hydrodistillation of the respective plant parts. Surfactants and formulation excipients such as sodium lauryl ether sulphate (SLES), sodium lauryl sulphate (SLS), cocodiethanolamine, cocobetaine, stearamide DEA, lauramide DEA, glycol stearate, EDTA, sodium hydroxide, potassium hydroxide, ethyl alcohol, and purified water were used for shampoo base preparation. Analytical reagents including anhydrous sodium sulphate, methyl red indicator, silver nitrate solution, and solvents such as methanol, chloroform, petroleum ether, and ethanol were employed for evaluation and analytical studies.

Extraction of Volatile Oils

The collected plant drugs were subjected to hydrodistillation for the extraction of volatile oils using a Clevenger-type apparatus. Each plant material was processed individually.

For extraction of cinnamon oil, the bark of *Cinnamomum zeylanicum* was dried, powdered, and 150 g of the powdered bark was subjected to hydrodistillation for 5–6 hours using a Clevenger apparatus. The obtained oil was separated, dried over anhydrous sodium sulphate to remove traces of moisture, and the percentage yield was calculated. The oil was stored in well-closed glass vials at 4 °C for further studies.

For extraction of eucalyptus oil**,** kapur tulsi oil, and cajeput oil, fresh leaves of *Eucalyptus globulus* and *Ocimum kilimandscharicum* were collected, washed, and cut into small pieces. About 150 g of leaves from each plant were separately subjected to hydrodistillation for 5–6 hours. The extracted oils were dried over anhydrous sodium sulphate, their percentage yields were calculated, and they were preserved in glass vials at 4 °C until further use.

The percentage yield of volatile oils was calculated using the following formula:

$$\text{Percentage yield of oil} = \frac{\text{Volume of oil obtained (ml)} \times 100}{\text{Weight of plant material taken (g)}}$$

Determination of Organoleptic and Physical Properties of Extracted Oils

The extracted oils were evaluated for organoleptic properties such as appearance, color, odor, taste, solubility, and specific gravity. These parameters served as indicators of purity, quality, and identity of the oils.

Method

Each oil sample was placed in a transparent container against a white background to observe color and clarity. The characteristic odor was assessed by gentle sniffing, and tactile properties were evaluated by rubbing a small quantity of oil between the thumb and forefinger.

Solubility was determined in various solvents including water, ethyl alcohol, methanol, chloroform, and petroleum ether. Specific gravity was determined at 25 °C and expressed as the ratio of the weight of a given volume of oil to the weight of an equal volume of distilled water at the same temperature.

Formulation of Herbal Anti-Dandruff Shampoo

Selection of Suitable Shampoo Base

Different shampoo bases were formulated and evaluated for physical stability, foam volume, and foam stability. The following bases were prepared and compared:

- **B1:** Coconut oil–based shampoo
- **B2:** Clear liquid shampoo
- **B3:** Cream shampoo

Based on stability and performance parameters, the most suitable base was selected for the final anti-dandruff formulation.

Table 1: Formulation of Coconut Oil Shampoo Base (B1)

Ingredient	Quantity
Coconut oil	15.0 ml
Palm oil	5.0 ml
Potassium hydroxide (90%)	3.0 ml
Sodium hydroxide (90%)	1.0 ml
Sodium lauryl sulphate	69.0 ml
Ethyl alcohol	7.0 ml

Method:

Coconut oil and palm oil were heated separately and then added to potassium hydroxide and sodium hydroxide with slow agitation (Punyoyai *et al.*, 2018). The mixture was gradually incorporated into sodium lauryl sulphate under constant stirring. After cooling, ethyl alcohol was added and mixed thoroughly.

Table 2: Formulation of Clear Liquid Shampoo Base (B2)

Ingredient	Quantity
Purified water	46 ml
Sodium lauryl ether sulphate	46 ml
Cocodiethanolamine	1 ml
Cocobetaine	6 ml

Method:

Sodium lauryl ether sulphate was added to purified water with constant stirring and mixed for 10 minutes. Cocodiethanolamine was then added, followed by cocobetaine with continuous stirring until a homogeneous formulation was obtained (Umar *et al.,* 2021).

Table 3: Formulation of Cream Shampoo Base (B3)

Ingredient	Quantity
Purified water	33.0 ml
Sodium hydroxide	0.4 ml
EDTA	0.1 ml
SLS (30%)	50.0 ml
Coconut fatty acids	3.0 ml
Stearamide DEA	5.0 ml
Lauramide DEA	5.0 ml
Glycol stearate	4.0 ml

Method:

Sodium hydroxide, EDTA, and coconut fatty acids were added to 20 ml of purified water and heated at 55–60°C to form a soap solution. The soap was diluted with additional water, followed by the addition of stearamide DEA, lauramide DEA, and glycol stearate. The mixture was heated for 5 minutes to ensure uniform mixing.

Stability Evaluation of Shampoo Bases

All three shampoo bases were divided into two portions. One portion was stored at 45 °C and the other at 5 °C for one month. After storage, the bases were evaluated for changes in appearance, color, odor, phase separation, foam volume, and foam stability. Based on these observations, the most stable base was selected for the formulation of the herbal anti-dandruff shampoo.

Formulation of Herbal Anti-Dandruff Shampoo

Based on antifungal activity and stability evaluation, the final shampoo was formulated using the optimized base.

Table 4: Formulation of Herbal Anti-Dandruff Shampoo

Ingredient	Quantity
Cinnamon oil	0.5 ml
Kapur tulsi oil	0.5 ml
Sodium lauryl ether sulphate	46 ml
Cocodiethanolamine	6 ml
Cocobetaine	1 ml
Purified water	46 ml

Method:

Cinnamon oil and kapur tulsi oil were added to purified water with continuous stirring. Sodium lauryl ether sulphate was then incorporated and stirred for 10 minutes. Cocodiethanolamine was added followed by cocobetaine, ensuring uniform mixing (Pierard-Franchimont *et al.,* 2001). The pH of the formulation was adjusted between 5.0 and 6.0.

Evaluation of Anti-Dandruff Shampoo Formulation

a) Determination of Non-Volatile Alcohol-Soluble Matter

The non-volatile alcohol-soluble matter indicates the amount of active and auxiliary ingredients present in the shampoo formulation.

Procedure:

About 10 g of the shampoo formulation was accurately weighed and transferred into a 150 ml beaker. The sample was evaporated on a steam bath until almost complete dryness. The residue was then digested with 50 ml of 96% ethyl alcohol by heating on a steam bath for approximately 2 minutes. The hot alcoholic solution was filtered through a sintered glass filter fitted to a Buchner flask. The beaker and residue were washed five times with 30 ml portions of ethyl alcohol (Chandran *et al.*, 2013).

The combined filtrate was transferred into a previously weighed wide-mouth flat-bottomed flask and evaporated nearly to dryness on a water bath. The remaining alcohol was removed by rotating the flask on the water bath. The flask was then heated in a hot air oven at 105 °C until a constant weight was obtained. The mass percent of residue (Y) was calculated:

$$Y = \frac{\text{Mass of residue obtained} \times 100}{\text{Mass of shampoo taken}}$$

The residue was dissolved in 50 ml of distilled water, and two drops of methyl red indicator were added. The solution was titrated with standard silver nitrate solution, using the same quantity of reagents for a blank determination. The chloride content, expressed as sodium chloride (X), was calculated using the formula:

$$X = \frac{V \times 0.5844}{M}$$

Where

V = volume (ml) of silver nitrate required for sample minus blank

M = mass (g) of shampoo taken

Determination of pH

The pH of shampoo is a critical parameter influencing hair quality, scalp compatibility, and minimization of eye irritation (Revansiddappa *et al.*, 2018).

Procedure:

The pH of a 10% w/v shampoo solution prepared in distilled water was measured at 25 °C using a calibrated digital pH meter (Maniker and Jolly, 2001).

Determination of Foam Height, Volume, and Stability

Foam generation and stability, although not directly related to cleansing efficiency, are important attributes affecting consumer acceptability.

Procedure:

Artificial sebum was prepared to simulate natural scalp sebum (Gloor, 1978), consisting of olive oil (20%), coconut oil (15%), oleic acid (15%), paraffin wax (15%), and cholesterol (20%). Foam volume was evaluated using the blender method (Aghel *et al.*, 2007).

A quantity of 0.25 ml of artificial sebum dissolved in hexane was added to 4 g of shampoo. About 40 ml of a 10% shampoo solution was blended for 5 seconds using a kitchen hand blender. The height of foam generated was measured immediately and after 3 minutes. The test was repeated using hard water and in the presence of artificial sebum.

Evaluation by Official and Unofficial Methods

Detergency Evaluation

Procedure:

Non-remi human hair tresses were prewashed with 5% sodium lauryl sulphate (SLS), dried, and cut into 10-inch, 3 g swatches. The hair swatches were immersed in 20 ml of 10% artificial sebum solution in hexane for 15 minutes with intermittent shaking. After solvent evaporation, the swatches were weighed to determine the sebum load (Potluri *et al.*, 2013).

Each swatch was divided into two equal portions: one treated with shampoo and the other used as an untreated control. The test swatch was washed with 0.1 ml of a 10%

shampoo solution using the finger method, dried using a hair dryer, and further dried in an oven at 60 °C for 4 hours. Sebum remaining on both test and control swatches was extracted using hexane and weighed.

Detergency was calculated as:

$$\text{Detergency (\%)} = 100 - \left(\frac{T \times 100}{C}\right)$$

Where

T = weight of sebum in test swatch

C = weight of sebum in control swatch

Wetting Ability Test

The wetting ability reflects the efficiency of surfactants present in the formulation.

Procedure:

The canvas disc wetting test was employed. Canvas discs of 1-inch diameter weighing approximately 0.44 g were immersed just below the surface of a 1% shampoo solution (Sharma *et al.*, 2011). The time required for the disc to begin sinking was recorded as the wetting time.

Measurement of Surface Tension

Surface tension was measured using the drop-weight method with a stalagmometer. A 10% shampoo dilution in distilled water was used, and measurements were performed at room temperature.

Viscosity Profile

Rheological behavior significantly influences the stability, flow, and aesthetic properties of shampoo formulations.

Method:

The viscosity profile of the shampoo was measured using a Brookfield synchroelectric viscometer (Model RVT) at 25°C. Measurements were recorded at different rotational speeds (0.5, 1, 2.5, 5, 10, 20, 50, and 100 rpm) to study non-Newtonian flow behavior (Chandran *et al.*, 2013).

Conditioning effect on human hair by Scanning Electron Microscopy (SEM)

The conditioning effect of the shampoo formulation was evaluated by examining cuticle integrity using SEM and compared with marketed shampoos.

Method:

Untreated hair samples were collected from a 25-year-old volunteer. The samples were divided into three groups: control (untreated), test shampoo (10%), and marketed shampoos (MS1 and MS6). Hair strands were subjected to repeated wash cycles, rinsed with distilled water, and dried. The samples were analyzed under SEM to observe cuticle smoothness and scale lifting (Shinde *et al.*, 2013).

Stability Studies

Stability studies were performed to assess physical and organoleptic stability during storage.

Method:

Shampoo samples were stored at 5 °C, 45 °C, and room temperature for six months. Evaluations were conducted at 1, 3, and 6 months for appearance, color, odor, pH, foam height, detergency, viscosity, and phase separation, in accordance with Bureau of Indian Standards specifications (Potluri *et al.*, 2013).

RESULTS AND DISCUSSION

The performance of the developed herbal anti-dandruff shampoo (TS) was evaluated and compared with six commercially available marketed shampoos (MS1–MS6) using key quality and performance parameters, including detergency, wetting time, surface tension, viscosity, and stability. The results obtained clearly demonstrate the effectiveness and acceptable physicochemical characteristics of the test shampoo formulation.

Detergency is a significant parameter reflecting the cleansing efficiency of a shampoo. As shown in Table 5, the test shampoo (TS) exhibited the highest detergency value (79.23 ± 0.43%) among all formulations tested. This value was superior to most marketed shampoos and slightly higher than MS5 and MS6, indicating efficient removal of sebum and soil from hair. The enhanced detergency of TS may be attributed to the optimized combination of surfactants along with herbal actives, which synergistically improve cleansing without compromising hair integrity.

Wetting time is an indicator of the ability of a shampoo to penetrate and wet the hair surface rapidly. Lower wetting time corresponds to better wetting efficiency. As presented in Table 6, the wetting time of TS (185 ± 0.01 sec) was comparable to and better than several marketed formulations such as MS1, MS2, and MS4. This suggests that the test shampoo possesses adequate surface activity, allowing rapid wetting of hair fibers, which is desirable for effective cleansing and user acceptability.

Surface tension measurements further supported the surface-active behavior of the formulation. Reduction in surface tension facilitates spreading and wetting of the shampoo solution over hair and scalp. Table 7 shows that TS exhibited a surface tension value of 33.4 ± 0.04 mN/m, which is comparable to marketed shampoos and close to the lower range observed among them. This indicates efficient surfactant action and supports the favorable wetting and detergency results observed for the test shampoo.

Viscosity profiling (Table 8) revealed that both the marketed shampoos and the test shampoo exhibited non-Newtonian, shear-thinning behavior, as evidenced by a decrease in viscosity with increasing rotational speed. The viscosity values of TS were within the acceptable range and comparable to marketed products, ensuring ease of pouring, spreading, and application. Adequate viscosity also contributes to better consumer perception and product stability.

Stability studies (Table 9) demonstrated that the test shampoo remained physically and chemically stable over a period of six months under different storage conditions. No changes were observed in physical appearance, color, or odor, indicating good formulation stability. Foam height, surface tension, detergency, and viscosity values remained consistent throughout the study period, confirming that the formulation retained its functional properties during storage. This stability suggests that the herbal components and surfactants used in the formulation are compatible and do not undergo degradation over time.

Table 5: Detergency of Marketed Shampoos and Test Shampoo (TS)

S. No.	Shampoo Code	Detergency (%)
1	MS1	60.5 ± 0.44
2	MS2	68.0 ± 0.31
3	MS3	62.6 ± 0.36
4	MS4	65.7 ± 0.25
5	MS5	78.8 ± 0.20
6	MS6	75.03 ± 0.12
7	TS	79.23 ± 0.43

Table 6: Wetting Time of Marketed Shampoos and Test Shampoo (TS)

S. No.	Shampoo Code	Wetting Time (sec)
1	MS1	208 ± 0.41
2	MS2	203 ± 0.11
3	MS3	189 ± 0.33
4	MS4	193 ± 0.44
5	MS5	180 ± 0.38
6	MS6	188 ± 0.19
7	TS	185 ± 0.01

Table 7: Surface Tension of Marketed Shampoos and Test Shampoo (TS)

S. No.	Shampoo Code	Surface Tension (mN/m)
1	MS1	34.9 ± 0.32
2	MS2	37.7 ± 0.02
3	MS3	32.8 ± 0.12
4	MS4	34.6 ± 0.03
5	MS5	34.6 ± 0.00
6	MS6	33.1 ± 0.42
7	TS	33.4 ± 0.04

Table 8: Viscosity Profile of Shampoo Formulation (TS) and Marketed Shampoos at Different RPM

Shampoo	0.5 rpm	1 rpm	2.5 rpm	5 rpm	10 rpm	20 rpm	50 rpm	100 rpm
MS1	18000	17400	15200	13100	11000	9500	8660	6134
MS2	22000	20000	19700	18500	17760	16600	10670	5598
MS3	25000	23100	21200	20240	18250	17500	15400	13000
MS4	28430	25000	23450	21220	18725	15250	13100	11400
MS5	30100	28330	26000	24445	21400	18200	15480	12260
MS6	29470	27580	24555	22660	20600	18350	15100	11890
TS	29260	27020	24113	21780	19500	16800	14440	12500

Table 9: Stability Studies of Anti-Dandruff Shampoo Formulation (TS)

Parameter	1 Month	2 Months	3 Months	6 Months
Physical appearance	No change observed	No change observed	No change observed	No change observed
Colour / Odour	No change observed	No change observed	No change observed	No change observed
Foam height & stability (distilled water)	179 ± 1.33	178 ± 1.02	180 ± 4.29	178 ± 1.12
Surface tension (mN/m)	33.0 ± 1.47	32.3 ± 0.73	32.41 ± 0.46	33.13 ± 3.03
Detergency (%)	76.02 ± 0.01	75.25 ± 0.04	76.18 ± 0.03	76.32 ± 0.31
Viscosity at 50 rpm (cP)	14,200 ± 1.22	14,330 ± 0.11	14,000 ± 1.83	14,450 ± 2.20

CONCLUSION

The present study successfully demonstrated the formulation and evaluation of a herbal anti-dandruff shampoo incorporating essential oils with proven antifungal and scalp-conditioning properties. The optimized test shampoo exhibited superior detergency, effective wetting ability, desirable surface tension reduction, and appropriate rheological behavior when compared with commercially available marketed shampoos. The formulation maintained a skin-friendly pH and showed good foaming characteristics and cleansing efficiency, which are essential for consumer acceptability. Stability studies confirmed that the shampoo formulation remained physically and functionally stable over a six-month storage period without any significant changes in appearance, odor, foam characteristics, surface tension, detergency, or viscosity.

DECLARATION OF INTEREST

The authors declare no conflicts of interests. The authors alone are responsible for the content and writing of this article.

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