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CROWNED BY NATURE: DEVELOPMENT OF A TERMINALIA TOMENTOSA–BASED HERBAL SHAMPOO

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ABSTRACT

Herbal medicines are widely used as alternatives to synthetic drugs because they are generally perceived to be safer and better tolerated, especially for long-term use. In topical and cosmetic formulations, plant-derived ingredients obtained from seeds, roots, leaves, bark, and flowers are employed for both therapeutic and aesthetic benefits. Within this context, herbal shampoos have gained importance as substitutes for conventional chemical-based cleansing products that often rely on synthetic surfactants. *Terminalia tomentosa*, a medicinal plant reported to possess significant antimicrobial and antioxidant activity, was selected as the principal herbal constituent in the present work. A shampoo formulation containing *Terminalia tomentosa* extract was developed and evaluated for its physicochemical characteristics, appearance test, pH measurement, solid content, foam volume and stability, dirt dispersion test and antimicrobial test. The overall objective of the study was to formulate and characterize an herbal antimicrobial shampoo incorporating *Terminalia tomentosa* that is suitable for routine use while maintaining acceptable safety and performance profiles.[1]

KEYWORDS: Herbal shampoo, Terminalia tomentosa, Antimicrobial activity, Phytochemicals.

INTRODUCTION

Herbal shampoos

Herbal shampoos are hair-cleansing formulations containing surface-active agents, available in forms such as liquids, emulsions, or gels. They are designed to effectively remove sebum, sweat, environmental impurities, and product residues from the scalp and hair, while minimizing irritation and preventing damage. As everyday cosmetic products, they are expected not only to clean but also to help maintain scalp health, improve hair feel, appearance, and enhance overall manageability. The selection of ingredients in such formulations is guided by their ability to provide mild

cleansing together with nourishing, conditioning, protective, and sometimes therapeutic benefits. In the present investigation, *Terminalia tomentosa* was incorporated as the key herbal active in a shampoo base to explore its potential role in antimicrobial hair and scalp care.[2]

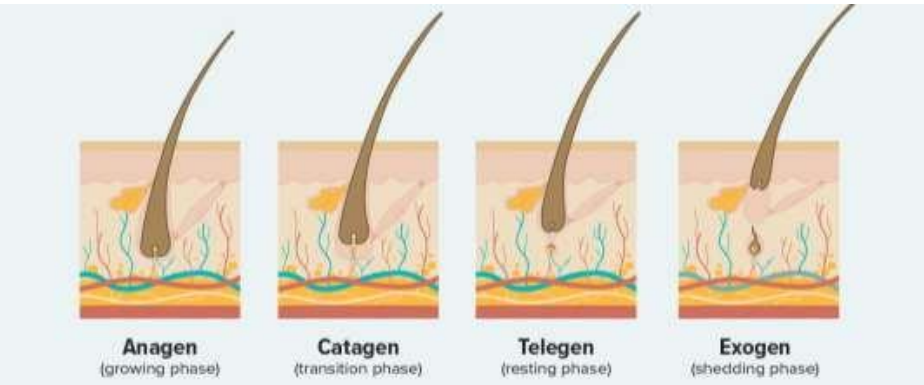
Structure and biology of hair

Hair is a distinctive feature of mammals and plays both aesthetic and physiological roles in humans. Beyond its contribution to appearance, it serves important biological functions such as protecting the scalp from ultraviolet radiation, assisting in thermoregulation, and facilitating the distribution of sebum and sweat across the skin surface. Each hair originates from a follicle embedded in the dermis, where specialized cells regulate its growth cycle through phases of anagen (active growth), catagen (transition), and telogen (resting). The hair shaft itself is primarily composed of keratin, a resilient fibrous protein that also forms nails and other cutaneous structures. Structurally, the shaft is organized into three concentric layers: the medulla at the core, the cortex providing tensile strength and elasticity through densely packed keratin fibers and melanin granules, and the cuticle forming a protective outer layer of overlapping keratinized cells arranged like scales. Surrounding the follicle are sebaceous glands that secrete lipids to lubricate the shaft, and arrector pili muscles that enable piloerection in response to cold or emotional stimuli. The vascular supply and dermal papilla at the follicle base ensure nutrient delivery and hormonal regulation, making hair a dynamic tissue that reflects both genetic programming and environmental influences.[3]

Hair growth cycle

Hair follicles undergo a dynamic cycle of growth and renewal, classically divided into four phases: anagen (growth), catagen (regression), telogen (resting), and exogen (shedding). During the anagen phase, the follicle is metabolically active, producing a growing hair fiber over months to years. Catagen marks a brief transition where cell proliferation halts and the follicle shrinks. In the telogen phase, the mature club hair remains anchored while a new germ forms beneath. Finally, the exogen phase involves the release of the old hair shaft, allowing the emerging fiber to surface.

Understanding this cycle is essential for evaluating how herbal shampoos interact with follicular activity and influence hair health.[3]



Common hair and scalp problems[4]

A variety of internal and external factors - including genetics, hormones, nutrition, environment, and cosmetic habits - can lead to hair and scalp issues.

The most reported problems include:

1. **Hair Fall / Excessive Shedding**: Loss of hair strands beyond normal daily shedding, often due to stress, hormonal imbalance, or poor nutrition.
2. **Alopecia (Hair Loss)**: Partial or complete hair loss, which may be genetic (e.g., androgenetic alopecia) or triggered by medical conditions.
3. **Dandruff**: Flaky white or yellowish scales on the scalp, often caused by fungal overgrowth or dry skin.
4. **Oily Scalp**: Excess sebum production leading to greasy hair and increased risk of dandruff or scalp acne.
5. **Dry and Brittle Hair**: Hair that lacks moisture, becomes rough, and breaks easily due to heat styling, harsh shampoos, or poor hydration.
6. **Split Ends**: Fraying or splitting of the hair shaft, usually from mechanical damage or chemical treatments.
7. **Patterned Hair Loss**: Thinning of hair in specific areas, commonly seen in male and female pattern baldness.
8. **Scalp Infections**: Conditions like folliculitis, seborrheic dermatitis, or fungal infections that cause inflammation, itching, or pustules.
9. **Itchy or Irritated Scalp**: Discomfort due to allergic reactions, product buildup, or microbial imbalance.
10. **Premature Greying**: Early loss of hair pigment, often linked to genetics, stress, or nutritional deficiencies.

Rationale for herbal shampoos

Herbal shampoos are formulated using plant-derived ingredients to offer effective cleansing while minimizing the adverse effects commonly associated with synthetic products. Conventional shampoos often rely on strong anionic or amphoteric surfactants, which, with prolonged use, may lead to scalp irritation, dryness, increased hair fragility, and discomfort around the eyes. In contrast, herbal formulations typically incorporate milder surfactant systems along with botanical extracts that provide conditioning, antimicrobial, antioxidant, and soothing properties. These benefits not only improve scalp health and hair texture but also enhance long-term tolerability. The rising consumer preference for natural, non-toxic, and eco-friendly products has driven interest in herbal cosmetics, making herbal shampoos a promising alternative for individuals seeking safer and more holistic hair care solutions. This project aims to explore and develop a herbal shampoo that aligns with these expectations, offering both efficacy and safety through scientifically selected ingredients.[5]

Advantages of herbal shampoos[6]

Herbal shampoos are considered superior to conventional chemical-based shampoos because they provide effective cleansing while minimizing harmful side effects. Their benefits can be summarized as follows:

- **Gentle Cleansing** – Mild surfactants clean without stripping natural oils.
- **Moisture Retention** – Natural oils and plant extracts keep hair hydrated and reduce brittleness.
- **Sebum and pH Regulation** – Helps balance scalp oil production and maintain healthy pH.
- **Reduced Hair Fall and Breakage** – Strengthens hair fibers and minimizes chemical damage.
- **Antioxidant and Antimicrobial Protection** – Shields against UV radiation and microbial imbalance.
- **Lower Risk of Irritation** – Fewer synthetic additives reduce allergic reactions and sensitivity.
- **Suitable for All Hair Types** – Compatible with diverse hair textures and conditions.
- **Improved Hair Texture and Appearance** – Supports softness, shine, and color retention.
- **Eco-Friendly and Biodegradable** – Plant-based ingredients reduce environmental impact.

Role of Terminalia tomentosa in hair care

Terminalia tomentosa, a species belonging to the genus *Terminalia*, is a deciduous tree native to India and widely recognized in traditional medicine systems for its therapeutic potential. Historically, extracts from its bark and leaves have been incorporated into oils and herbal remedies, particularly for maintaining scalp health and enhancing hair quality. The plant is rich in phytoconstituents such as tannins, flavonoids, and phenolic compounds, which impart antimicrobial, antioxidant, and anti-inflammatory properties. These bioactive compounds help protect scalp tissues and hair follicles from oxidative stress, reduce microbial colonization, and soothe inflammatory conditions, thereby creating a healthier environment for hair growth. In hair care, *Terminalia tomentosa* has been valued for its ability to strengthen roots, support natural pigmentation, and improve overall hair texture. On this basis, it has been selected as a principal herbal active in the present shampoo formulation, aimed at combining gentle cleansing with supportive scalp care through the benefits of a traditionally trusted botanical source.[2]

AIMS AND OBJECTIVES OF THE STUDY

Need for the study

Hair plays a vital role in personal appearance and emotional confidence, and its condition reflects the combined influence of genetics, lifestyle, environment, and cosmetic practices. Common concerns such as hair fall, dandruff, dryness, premature greying, and reduced volume are often worsened by repeated use of chemical-based shampoos that contain harsh surfactants and synthetic additives. While these conventional products effectively remove sebum and debris, they may also cause scalp irritation, dryness, and long-term damage to the hair shaft. This has led to increased interest in herbal formulations that use plant-derived ingredients and are considered safer for prolonged use.

Terminalia tomentosa, a medicinal plant native to India, is known for its antimicrobial, antioxidant, and anti-inflammatory properties, making it a promising candidate for scalp care. Despite its traditional use, there is limited systematic research on its incorporation into shampoo formulations and its physicochemical and antimicrobial performance. Therefore, this study aims to develop and evaluate a herbal shampoo containing *Terminalia tomentosa* extract, offering gentle cleansing and enhanced scalp benefits, and to compare its quality attributes with those of marketed herbal shampoos.[5]

Objectives of the study Primary Objective

- To formulate and evaluate a herbal shampoo containing an extract of *Terminalia tomentosa*, with emphasis on its physicochemical characteristics and antimicrobial activity.

Secondary Objectives

- To extract and prepare a suitable *Terminalia tomentosa* herbal extract for incorporation into a shampoo base.
- To develop a stable herbal shampoo formulation using *Terminalia tomentosa* and appropriate excipients.
- To assess key physicochemical parameters of the formulated shampoo, including appearance, pH, solid content, foam volume, surface tension, and dirt dispersion.
- To compare the evaluated parameters of the formulated *Terminalia tomentosa* shampoo with those of a marketed herbal shampoo.
- To explore the potential of *Terminalia tomentosa*-based shampoo as a safer, plant-derived alternative to conventional chemical shampoos for routine hair and scalp care.

Formulation components[7]

The herbal shampoo was formulated using a combination of cleansing, conditioning, soothing, and preservative agents to achieve effective yet gentle hair and scalp care. The key components and their roles are:

- Soapnut (Sapindus species): Natural surfactant rich in saponins; provides primary cleansing and foam formation.
- Sodium Lauryl Sulfate (SLS): Additional detergent and foaming agent; enhances lather and sebum removal.
- Gelatin (10% base): Thickening and film-forming agent; improves viscosity and supports smoother hair feel.
- Castor Oil: Conditioning agent; retains moisture, reduces breakage, and supports scalp comfort.
- Lavender Oil: Soothing and aromatherapeutic constituent; provides fragrance, antimicrobial, and calming effects.
- Rose Water: Perfuming and mild hydrating agent; maintains scalp pH and enhances softness and shine.
- Methyl Paraben: Preservative; prevents microbial contamination and ensures product stability during storage.

METHODOLOGY

Extraction of *Terminalia Tomentosa* (Indian lauryl leaf)

Sl. No	Material	Purpose	Quantity
01	Terminalia tomentosa leaves	Source of bioactive phytoconstituents for extraction	50 g
02	Sheets	To spread leaves in a thin layer for shade-drying	4
03	Grinder / mixer	To convert shade-dried leaves into coarse powder	1
04	Sieve	To obtain uniform particle size of leaf powder	1
05	Analytical balance	For accurate weighing of plant material	1
06	Soxhlet apparatus	For continuous hot extraction of ethanol-soluble constituents from the plant powder	1 set
07	RBF	To hold ethanol solvent during Soxhlet extraction	1
08	Condenser	To condense ethanol vapors and allow continuous reflux	1

		during Soxhlet extraction	
09	Ethanol	Solvent	500 ml
10	Heating mantle	To provide controlled heating for reflux during Soxhlet extraction	1
11	Filter paper	To remove suspended particles from the extract	7
12	Beaker	To collect the ethanolic extract	1
13	Water bath	To gently concentrate the extract by evaporating ethanol at controlled temperature	1
14	China dish	For evaporating and concentrating the extract to a viscous crude extract	1
15	Spatula	To aid in transfer and scraping of extract	1
16	Airtight container	To store the concentrated crude Terminalia tomentosa extract until further use	1

Extraction procedure of *Terminalia Tomentosa*[8]

Weigh 50 g Terminalia tomentosa leaf powder

↓

Load powder into Soxhlet thimble

↓

Add 500 ml ethanol to round-bottom flask

↓

Assemble Soxhlet apparatus with condenser

↓

Reflux for ~3 hours (repeated siphon cycles)

↓

Collect ~400 ml ethanolic extract

↓

Concentrate on water bath to dryness

↓

Obtain crude Terminalia tomentosa leaf extract and store airtight

Collection and preparation of plant material

Fresh leaves of Terminalia tomentosa were collected from local areas in the vicinity of the study site and authenticated based on their macroscopic characteristics. The collected leaves were washed with clean water to remove adhering dust and foreign matter, then spread in a single layer and dried under shade at room temperature to minimize degradation of heat- or light-sensitive phytoconstituents. Shade-drying was continued for approximately one week, with occasional turning to ensure uniform drying and to prevent fungal growth. After complete drying, the leaves were coarsely powdered using a domestic mixer grinder and passed through an appropriate mesh to obtain a uniform leaf powder suitable for extraction. Accurately 50 g of this Terminalia tomentosa leaf powder was weighed and stored in an airtight container until extraction.

Figure 4.1: Dried leaves of Terminalia tomentosa.

Figure 4.2: Powder of dried leaves.

Soxhlet extraction with ethanol

A weighed quantity (50 g) of Terminalia tomentosa leaf powder was carefully transferred into a cellulose extraction thimble and placed in the main chamber of entire assembly was fitted with a reflux condenser. The system was placed on a heating mantle and gently heated to allow the ethanol to boil, vaporize, and condense in the Soxhlet chamber, thereby continuously percolating through the leaf powder. When the solvent level in the chamber reached the top of the siphon arm, the ethanolic extract was automatically siphoned back into the boiling flask, completing one extraction cycle. This process of filling, percolation, and siphoning was allowed to proceed repeatedly for approximately 3 hours, ensuring exhaustive extraction of ethanol-soluble phytoconstituents from the leaf powder. At the end of the extraction, the apparatus was allowed to cool, and about 400 ml of the combined ethanolic a Soxhlet apparatus. A round-bottom flask containing 500 ml of ethanol was attached to the Soxhlet extractor, and the extract was collected from the round-bottom flask.

Figure 4.3: Soxhlet extraction with ethanol.

Concentration of extract

The ethanolic extract of *Terminalia tomentosa* leaves was filtered and concentrated on a water bath below ethanol's boiling point to avoid degrading sensitive constituents. A viscous mass was obtained, cooled, and stored in an airtight container under refrigeration for later use in shampoo formulation.

Figure 4.4: Filtration of ethanolic extract.

Figure 4.5: Ethanolic extract in a China dish.

Figure 4.6: Concentrated mass of Terminalia tomentosa leaf extract.

Phytochemical Screening of Terminalia tomentosa Extract[8]

Standard qualitative phytochemical tests were carried out on the ethanolic extract of Terminalia tomentosa leaves to detect major classes of bioactive constituents.

- **Alkaloids – Dragendorff's Test**: 2 ml of extract was acidified with dilute HCl and treated with Dragendorff's reagent. Formation of an orange-red precipitate indicates the presence of alkaloids in the extract.
- **Flavonoids – Alkaline Reagent Test**: 1 ml of extract was mixed with 2 ml of 2% NaOH solution. Development of an intense yellow color that becomes colorless on addition of dilute HCl confirms the presence of flavonoids.
- **Phenolic Compounds – Ferric Chloride Test**: 2 ml of extract was treated with a few drops of 5% $FeCl_3$ solution. Appearance of a deep blue-green to blue-black coloration indicates the presence of phenolic compounds and tannins.
- **Steroids – Salkowski Test**: 2 ml of extract was mixed with chloroform, followed by careful addition of concentrated H_2SO_4 along the side of the test tube. Formation of a reddish-brown or brown ring at the interface suggests the presence of steroidal constituents.
- **Glycosides – Keller–Killiani Test**: 2 ml of extract was treated with glacial acetic acid containing a trace of $FeCl_3$, then under-layered with concentrated H_2SO_4. Development of a reddish-brown ring at the junction with a bluish-green layer above indicates the presence of cardiac glycosides.
- **Tannins – Ferric Chloride Test**: A portion of extract was mixed with neutral 5% ferric chloride solution. Formation of a deep blue-black coloration confirms the presence of tannins.

Formulation of Herbal shampoo[9]

Formulation of Terminalia tomentosa herbal shampoo (batch size: 20 ml)

Sl. No	Material	Purpose	Quantity
01	Terminalia tomentosa extract	Herbal active, antimicrobial & antioxidant agent	2.5 ml
02	Soapnut	Primary natural surfactant and foaming agent	1 g
03	Sodium lauryl sulfate	Additional surfactant, improves lather and cleansing	6 g
04	10% Gelatin solution	Thickening and viscosity-building agent	q.s
05	Castor oil	Conditioning agent, enhances softness and shine	3 ml
06	Lavender oil	Soothing and perfuming agent	3 ml

07	Rose water	Co-solvent, perfuming and mild hydrating agent	q.s
08	Methyl paraben	Preservative to prevent microbial growth	1 ml
09	Distilled water	Solvent for soapnut decoction and aqueous phase	q.s

Formulation of herbal shampoo Procedure

Soapnut (in 10 ml distilled water) boiled 20 min

↓

Filter and collect soapnut decoction

↓

Mix soapnut filtrate + 10% gelatin solution + rose water

↓

Warm aqueous phase to 40–50 °C

↓

Dissolve sodium lauryl sulfate + methyl paraben in warm aqueous phase with stirring

↓

Separately mix and gently warm lavender oil + castor oil

↓

Add oil phase slowly to aqueous phase at ~40 °C with continuous stirring

↓

Cool mixture to room temperature

↓

Incorporate Terminalia tomentosa leaf extract with gentle mixing

↓

Adjust final volume to 20 ml with rose water/gelatin solution

↓

Transfer formulated shampoo to clean container for evaluation

Preparation of the aqueous surfactant base

Soapnut was used as the primary natural surfactant. 1 g of soapnut was boiled with 10 ml of distilled water for about 20 minutes to obtain a saponin-rich decoction. The hot mixture was filtered, and the clear filtrate was collected as soapnut extract. This filtrate was then combined with an appropriate volume of 10% gelatin solution and rose water to form the aqueous phase, which was gently heated to 40–50 °C in a water bath to aid dissolution of other ingredients. Sodium lauryl sulfate and methyl paraben were added to this warm aqueous phase and stirred continuously until fully dissolved, providing additional foaming capacity and preservation, respectively.

Preparation of the oil phase and emulsification

In a separate container, castor oil and lavender oil were mixed thoroughly and slightly warmed to facilitate blending and to improve miscibility with the aqueous phase. The warm oil mixture was then added slowly, in a thin stream, to the aqueous phase maintained at approximately 40° C, with constant stirring to ensure uniform dispersion and formation of a stable shampoo base.

Incorporation of *Terminalia tomentosa* extract and final adjustment

After emulsification, the shampoo base was allowed to cool to room temperature. The pre-prepared *Terminalia tomentosa* leaf extract was then incorporated gradually with gentle stirring. The final volume of the formulation was adjusted to 20 ml using rose water and 10% gelatin solution to achieve the desired consistency and appearance. The finished herbal shampoo was transferred into a clean, airtight container and stored at room temperature for subsequent physicochemical evaluation and antimicrobial studies.

Comprehensive Evaluation Parameters

1. Appearance Test[9]

Objective: To evaluate and compare the visual characteristics of the formulated herbal shampoo and a marketed herbal shampoo, including color, clarity, and homogeneity.

Procedure: Both shampoo samples were examined under standardized daylight conditions. Color uniformity was assessed by visual comparison. Clarity was evaluated by inspecting for suspended particles or turbidity. Homogeneity was checked by gently shaking each sample to observe any phase separation.

Acceptance Criteria: Uniform color, clear appearance without suspended matter, and no phase separation.

2. pH Measurement[10]

Objective: To determine and compare the pH of the formulated herbal shampoo and a marketed herbal shampoo, ensuring compatibility with scalp and hair.

Procedure: A 10% solution of each shampoo sample was prepared at room temperature. A calibrated digital pH meter was used to measure the pH of both solutions under identical conditions.

Acceptance Criteria: pH between 5.0–7.0, suitable for scalp comfort and hair health.

3. Foam Volume and Stability[10]

Objective: To assess and compare the foaming ability and stability of the formulated herbal shampoo and a marketed herbal shampoo.

Procedure: A 10% solution of each shampoo sample was prepared in a graduated cylinder. The cylinder was shaken vigorously for 1 minute, and the foam height was recorded immediately. Foam stability was assessed by measuring the foam height again after 5 minutes.

***Acceptance Criteria*:** Adequate foam volume with stability maintained for at least 5 minutes.

4. Solid Content Test[10]

Objective: To determine and compare the solid content of the formulated herbal shampoo and a marketed herbal shampoo.

Procedure: A known volume of each shampoo sample was placed in an evaporating dish and heated at 105 °C until constant weight was achieved. The residue was weighed and expressed as a percentage of the original sample volume. The solid content was determined by the following formula

$$Solid\ content\ (\%) = \frac{weight\ of\ dried\ residue}{weight\ of\ original\ sample} \times 100$$

Acceptance Criteria: Solid content within acceptable range (20–30%), ensuring proper consistency.

5. Dirt Dispersion Test[10]

Objective: To evaluate and compare the ability of the formulated herbal shampoo and a marketed herbal shampoo to disperse dirt particles.

Procedure: A small amount of ink was added to a test tube containing diluted shampoo solution (10%) for both samples. Each test tube was shaken gently and observed for the dispersion of dirt particles and their tendency to settle on the foam.

***Acceptance Criteria*:** Dirt particles should remain dispersed in the solution and not settle on foam.

6. Antimicrobial Activity[8]

Objective: To assess and compare the antimicrobial potential of the formulated herbal shampoo and a marketed herbal shampoo.

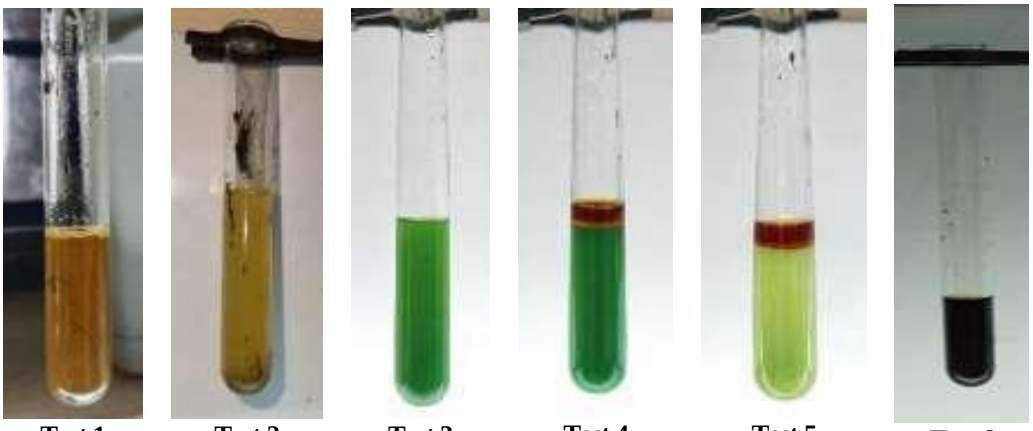
Procedure: The agar well diffusion method was used against selected microbial strains (*e.g., Staphylococcus aureus, Escherichia coli*). Wells were filled with equal volumes of each shampoo sample, and plates were incubated under suitable conditions. Zones of inhibition were measured in millimeters to determine antimicrobial activity.

Acceptance Criteria: Clear zones of inhibition indicating antimicrobial activity.

RESULTS AND DISCUSSIONS

Phytochemical Screening of Terminalia tomentosa Extract

Sl. No.	Phytoconstituent	Test Name	Procedure	Inference
01	Alkaloids	Dragendorff's Test	1 mL of Dragendorff's reagent + 2 mL extract	Formation of orange-red precipitate
02	Flavonoids	Lead Acetate Test	Add lead acetate solution to a portion of extract residue	Formation of yellow precipitate
03	Phenolic Compounds	Ferric Chloride Test	Mix extract with 5% w/v $FeCl_3$ solution	Formation of green color
04	Steroids	Salkowski Test	Dissolve extract in chloroform, add few drops of conc. H_2SO_4	Formation of brown ring with lower green layer
05	Glycosides	Keller–Killiani Test	Mix glacial acetic acid + $FeCl_3$, then add conc. H_2SO_4	Reddish-brown ring observed
06	Tannins	Ferric Chloride Test	Mix extract with neutral ferric chloride solution	Deep blue-black color



Test 1 **Test 2** **Test 3** **Test 4** **Test 5** **Test 6**

Comprehensive Evaluation Parameters

1. Appearance Test

Sample Code	Colour Uniformity	Clarity	Homogeneity	Overall Appearance
Formulated Shampoo	Uniform	Clear	No phase separation	Acceptable
Marketed Herbal Shampoo	Uniform	Clear	No phase separation	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for visual characteristics. Both samples exhibited uniform color, clear appearance without suspended matter, and no phase separation upon shaking. These findings meet the acceptance criteria for appearance. The formulated shampoo showed comparable results to the marketed herbal shampoo, confirming its acceptable visual quality and stability.

Figure 5.1: Formulated herbal shampoo showing uniform colour, clarity, and no phase separation.

2. pH Measurement

Sample Code	pH Value	Within acceptable range	Overall evaluation
Formulated Shampoo	6.5	Yes (5.0–7.0)	Acceptable
Marketed Herbal Shampoo	6.0	Yes (5.0–7.0)	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for pH compatibility with scalp and hair. The pH values of both samples (6.5 and 6.0) fell within the acceptable range of 5.0–7.0, ensuring scalp comfort and hair health. These findings confirm that the formulated shampoo is comparable to the marketed herbal shampoo in terms of pH balance, meeting the acceptance criteria for consumer use.

Figure 5.2: pH measurement of the formulated herbal shampoo.

3. Foam Volume and Stability

Sample Code	Foam Height (Immediate)	Foam Height (After 5 min)	Stability	Overall Evaluation
Formulated Shampoo	10 mL	6 mL	Stable	Acceptable
Marketed Herbal Shampoo	10 mL	8 mL	Stable	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for foaming ability and stability. The immediate foam heights were adequate (10 mL and 10 mL), and both samples maintained foam stability after 5 minutes with only slight reduction in height. These findings meet the acceptance criteria for foam volume and stability. The formulated shampoo demonstrated comparable foaming properties to the marketed herbal shampoo, confirming its suitability for consumer use.

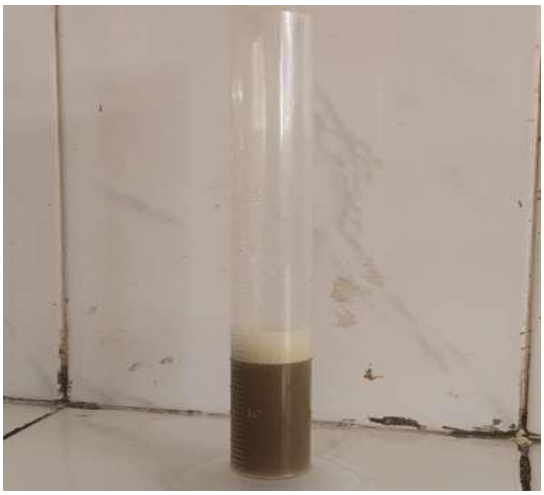


Figure 5.3: Graduated Cylinder Showing Foam volume and Stability of Formulated Herbal Shampoo.

4. Solid Content Test

Calculation

For formulated Shampoo

- Weight of original sample = 1.00 g
- Weight of dried residue = 0.245 g

$$Solid\ content\ (\%) = \frac{0.245}{1.00} \times 100 = 24.5\%$$

For marketed Herbal Shampoo

- Weight of original sample = 1.00 g
- Weight of dried residue = 0.252 g

$$Solid\ content\ (\%) = \frac{0.252}{1.00} \times 100 = 25.2\%$$

Sample Code	Solid Content (%)	Within Acceptable Range (20–30%)	Overall Evaluation
Formulated Shampoo	24.5	Yes	Acceptable
Marketed Herbal Shampoo	25.2	Yes	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for solid content by evaporating a known volume at 105 °C until constant weight was achieved. The solid content values (24.5% and 25.2%) fell within the acceptable range of 20–30%, ensuring proper consistency. These findings confirm that the formulated shampoo has suitable solid content comparable to the marketed herbal shampoo, meeting the acceptance criteria for consumer use.

Figure 5.4: Solid content test showing dried residue of formulated herbal shampoo after water bath drying.

5. Dirt Dispersion Test

Sample Code	Observation	Overall Evaluation
Formulated Shampoo	Dirt particles dispersed uniformly; no settling on foam	Acceptable
Marketed Herbal Shampoo	Dirt particles dispersed uniformly; no settling on foam	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for their ability to disperse dirt particles using the ink dispersion method. In both cases, dirt particles remained evenly dispersed in the solution and did not settle on the foam layer. These findings meet the acceptance criteria for dirt dispersion. The formulated shampoo demonstrated cleansing efficiency comparable to the marketed herbal shampoo, confirming its suitability for consumer use.

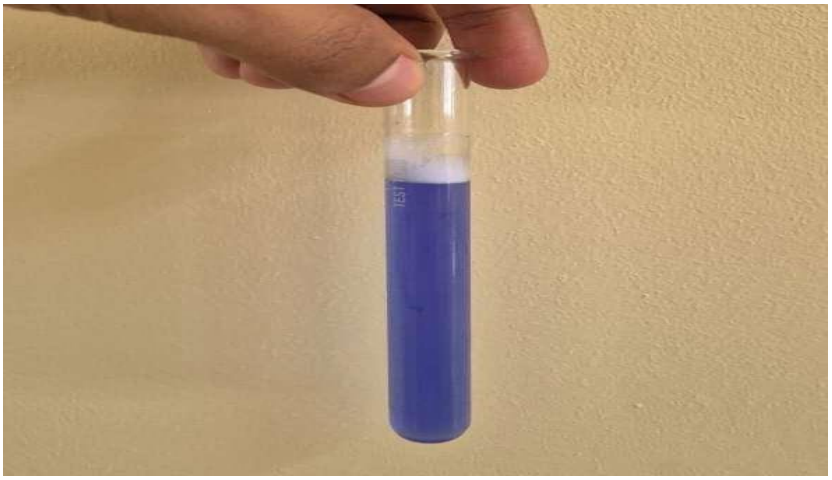


Figure 5.5: Test Tube Showing Foam Formation During Dirt Dispersion Test.

6. Antimicrobial Activity

Sample Code	Zone of Inhibition (mm)	Meets Criteria	Overall Evaluation
Formulated Shampoo	15 mm	Yes	Acceptable
Marketed Herbal Shampoo	16 mm	Yes	Acceptable

Result Interpretation

Both the formulated shampoo and the marketed herbal shampoo were evaluated for antimicrobial potential using the agar well diffusion method against selected microbial strains. Clear zones of inhibition were observed for both samples (15 mm and 16 mm), confirming antimicrobial activity. These findings meet the acceptance criteria, and the formulated shampoo demonstrated antimicrobial effectiveness comparable to the marketed herbal shampoo, supporting its suitability for scalp and hair hygiene.

Figure 5.6: inoculated agar plate beforeshampoo introduction.

Figure 5.7: Zone of Inhibition with Marketed Herbal Shampoo.

Figure 5.8: Zone of Inhibition with Formulated Herbal Shampoo.

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