FORMULATION & EVALUATION OF HERBAL HAIR SERUM

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Abstract:

The increasing demand for natural and chemical-free personal care products has inspired the development of a water-based herbal hair serum formulated with carefully selected plant-based ingredients known for their effectiveness in hair care and scalp health. This research focuses on the formulation, standardization, and evaluation of a herbal hair serum incorporating Hibiscus rosa-sinensis (hibiscus flower extract), Mentha arvensis (pudina oil), Azadirachta indica (neem bark extract), Glycyrrhiza glabra (mulethi), natural preservatives, Vitamin E capsules, and a suitable gelling agent.

Each ingredient in the formulation serves a unique purpose: Hibiscus promotes hair growth and prevents premature greying; Pudina oil provides a cooling effect and improves blood circulation to the scalp; Neem bark extract acts as a powerful antimicrobial agent against dandruff-causing pathogens; Mulethi soothes the scalp and strengthens hair roots; Vitamin E nourishes and protects the hair from oxidative damage. The use of a natural gelling agent ensures a smooth and non-greasy texture suitable for easy application and absorption.

The formulation process included aqueous extraction of the herbal components, filtration, mixing with oils and Vitamin E, and final blending with the gel base. The serum was evaluated for organoleptic properties, pH, viscosity, spreadability, stability, and microbial safety. The results indicated that the serum possesses desirable physicochemical characteristics, user-friendly application, and excellent stability without the use of synthetic preservatives or harsh chemicals.

This herbal hair serum provides a holistic approach to hair care by combining traditional knowledge with modern formulation techniques. It is safe for long-term use and offers multiple benefits such as hair strengthening, nourishment, dandruff control, and scalp rejuvenation. Hence, it holds great potential as a natural alternative to commercially available synthetic hair care products.

Key Words: Hair, Hair Serum, Dandruff, Hair Growth, etc

1. INTRODUCTION

Hair:

Hair is a complex structure composed of keratin and serves as a protective covering for the body. It is primarily made up of two main parts: the hair shaft, which is the visible part, and the hair follicle, which is embedded in the skin. Hair plays an essential role in protecting the scalp, regulating body temperature, and contributing to an individual's appearance. The structure of hair varies based on genetic, environmental, and health factors. Proper hair care is crucial to maintain healthy hair and prevent damage from external factors.

Type of Hairs:

1. Straight
2. Wavy
3. Curly
4. Coily

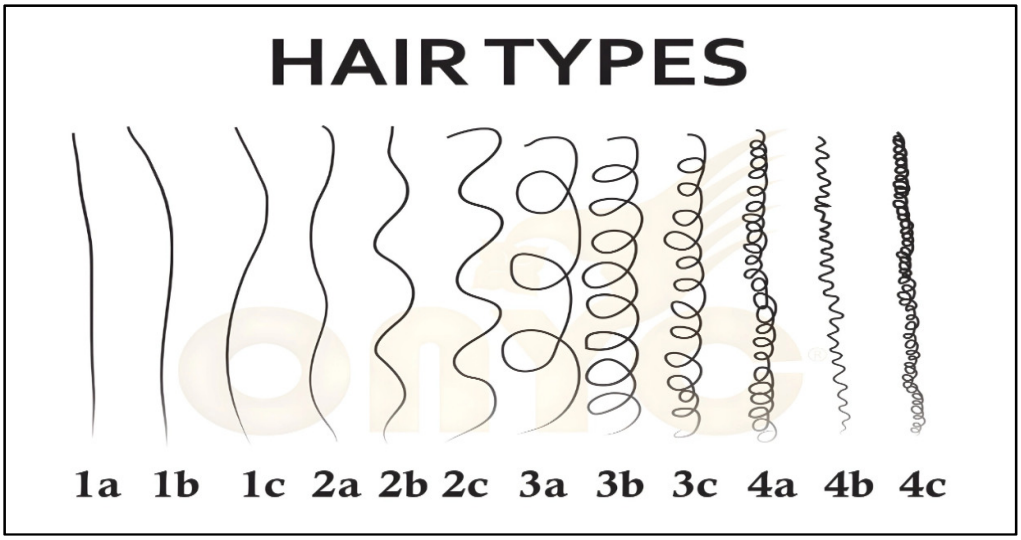


Fig. Subtypes of Hair

Structure and Composition of Human Hair:

1. Hair Shaft:

→ The visible part of the hair that protrudes above the skin.

2. Hair Root:

→ The part of the hair embedded in the skin, surrounded by the hair follicle.

3. Hair follicle:

→ A tubelike pocket of the epidermis that encloses a small section of the dermis at its base, where new hair cells are constantly being made.

4. Hair Layers:

→ Human hair consists of three main layers:

- The Cuticle - The outermost layer made up of tightly packed scales that protect the inner layers from damage and moisture loss.
- The Cortex - The middle layer responsible for hair strength, elasticity, and pigment. It contains melanin, which determines hair colour.
- The Medulla - The innermost layer, which is sometimes absent in fine or light-coloured hair. It provides structural support to the hair shaft.

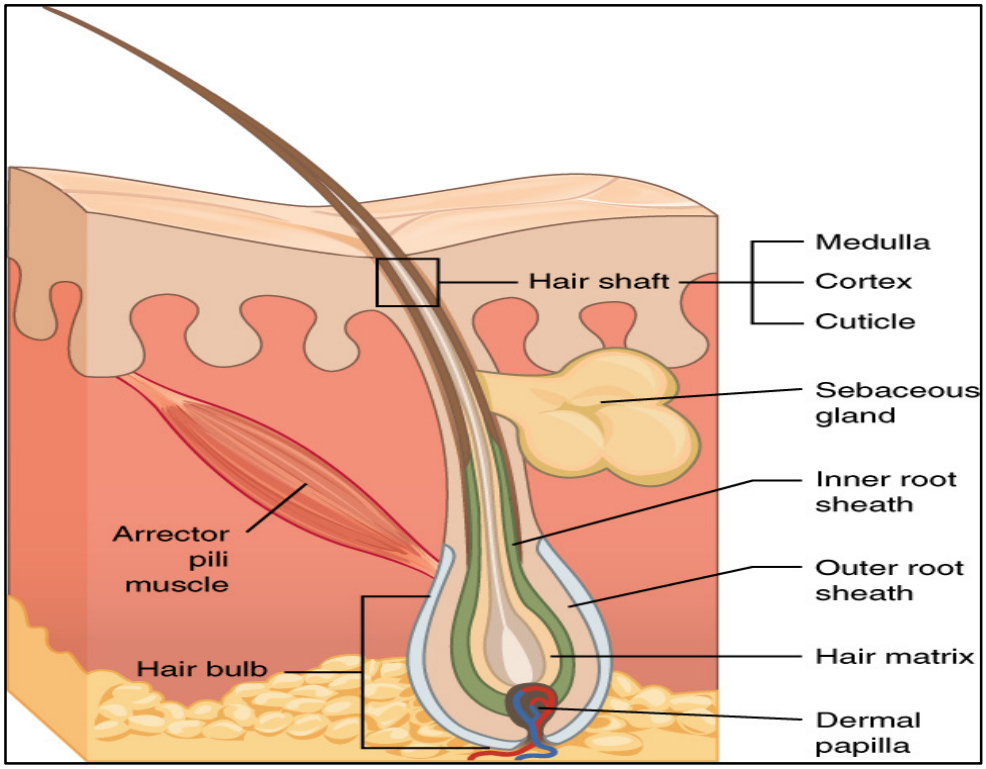


Fig. Structure of Hair

5. Keratin:

→ Hair is mainly made of keratin, a strong fibrous protein that also forms skin and nails.

6. Sebaceous Glands:

→ Follicles are also connected to sebaceous glands, which produce oil.

7. Arrector Pili Muscles:

→ Each hair follicle is attached to a tiny muscle (arrector pili) that can make the hair stand up (like goosebumps).

8. Hair Bulb:

→ Located at the base of each hair follicle, containing growing hair cells.

9. Hair Papilla:

→ Found inside the bottom of the hair bulb, supplying the hair root with blood.

10. Melanin:

→ The pigment that gives hair its colour, produced by melanocytes in the hair bulb.

Hair Growth Cycle:

Hair grows in a cyclic process involving five distinct phases:

1) Anagen Phase:
First stage of hair growth cycle & approximately 1,000 days. It begins in papilla & can last from. two - six years. Eighty to ninety percent of all human in anagen stage. Period of growth when cell around the Follicle rapidly dividing of depositing materials within the hair. The hair being able to grow 1 meter. The hair growth determined by genetics. The cells in papilla divide to produce new hair Fibers & Follicle buries itself into dermal layer of Skin to nourish the strand.

2) Catagens phase:
At the end of anagen phase, hair enters catagen phase. Short transitional phase, lasts approximately 10 days. First sign of Catagen is cessation of melanin production in hair bulb & apoptosis of follicular melanocytes. Also known as transitional phase follicle renew itself Two weeks hair follicle shrinks. Due to disintegration & papilla detaches & rest Cutting hair strand off from its nourishing blood Supply. Hair not grows during this phase length of terminal fibre increases follicle pushes them upward.

3] Telogen phase:
The final stage of hair growth. During phase hair follicle is dormant/ resting & hair easily lost 10-18% hair in telogen phase. Follicle then remain inactive for 3 months. The epidermal Cells lining follicle Channel Continue to grow & accumulate around base of hair. The follicle will begin to grow phase within two weeks the new hair shaft will begin to emerge once the telogen phase is complete. The process results in normal hair loss known as shedding.

4] Exogen phase:
For long hair shedding function has been assumed to be part of telogen phase, but now it has been shedding actually occurs as distinct phase termed as exogen phase. The shedding of hair fibre highly controlled active process. The process different from quiescence normally found during hair follicle cycling. The process of has two steps: After telogen the follicle base cells receive signal initiate exogen. Turn on effectors of shedding.

5] Kenogen phase:
The empty hair follicle noticed after shedding of hair fibre. Kenogen means hair follicle remains empty after telogen & before new anagen hair reappears. Hair loss, hair thinning & problems with hair growth occur when growth cycle is disrupted.

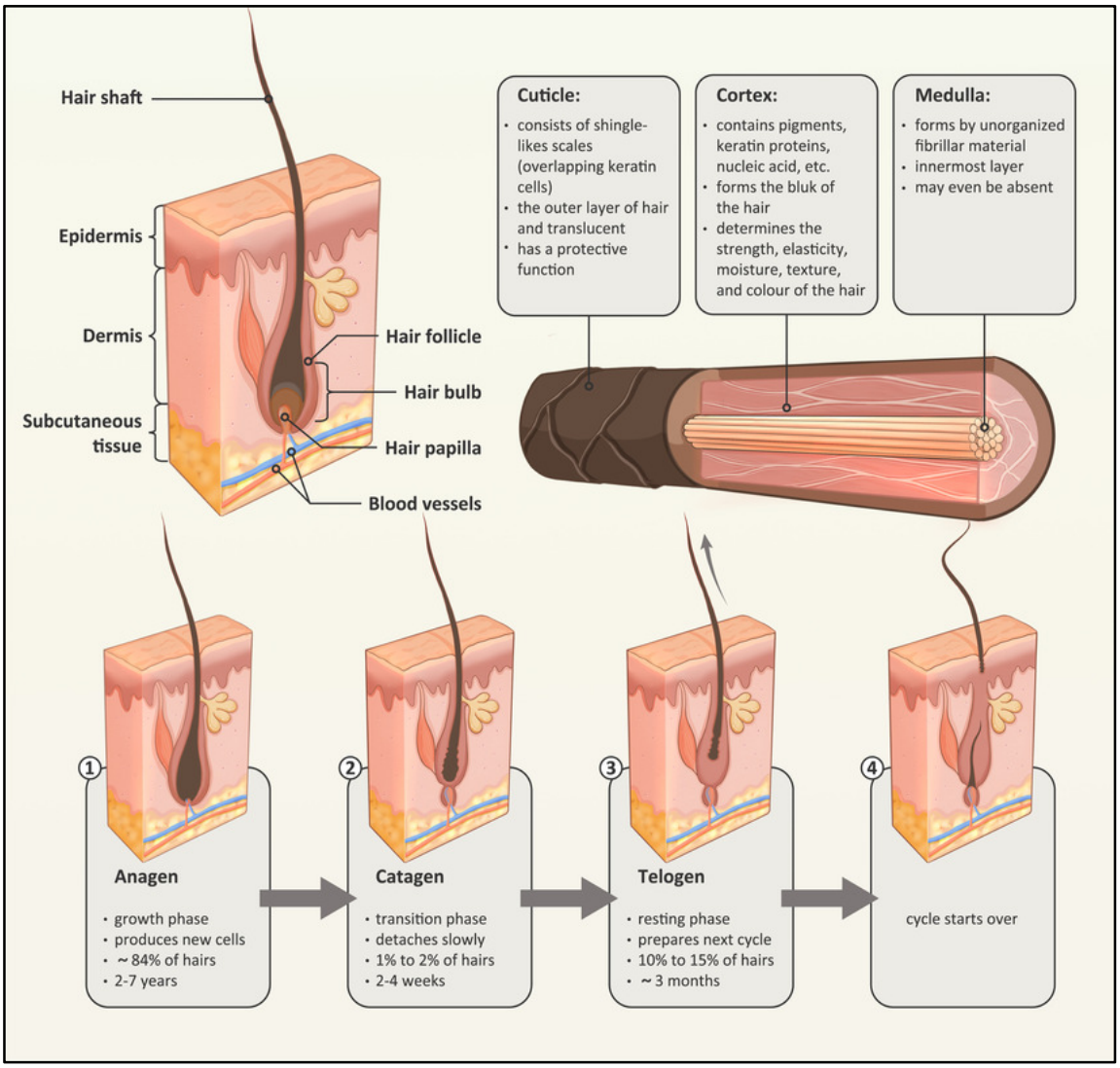


Fig. Hair Growth Cycle

Hair Problems and their Causes:

1. Dandruff:
   Problem: Flaky scalp and itchy skin.
   Causes: Overactive yeast on the scalp, dry skin, and certain medical conditions.

2. Hair Loss:
   Problem: Excessive shedding of hair, leading to thinning or baldness.
   Causes: Genetics, hormonal imbalances, stress, poor nutrition, and certain medical conditions.

3. Split Ends:
   Problem: Damaged hair ends that split and fray.
   Causes: Heat styling, chemical treatments, and improper hair care.

4. Dry Hair:
   Problem: Hair that lacks moisture, appears dull, and is prone to breakage.
   Causes: Over-shampooing, harsh chemicals, heat styling, and poor nutrition.

5. Oily Hair:
   Problem: Excess oil production on the scalp, making hair appear greasy and weighed Down.
   Causes: Overactive sebaceous glands, certain products, and stress.

6. Frizzy Hair:
   Problem: Unruly, dry, and unmanageable hair.
   Causes: Dryness, humidity, and improper hair care.

7. Dull or Damaged Hair:
   Problem: Hair that lacks shine and appears lifeless or brittle.
   Causes: Heat styling, chemical treatments, and poor hair care.

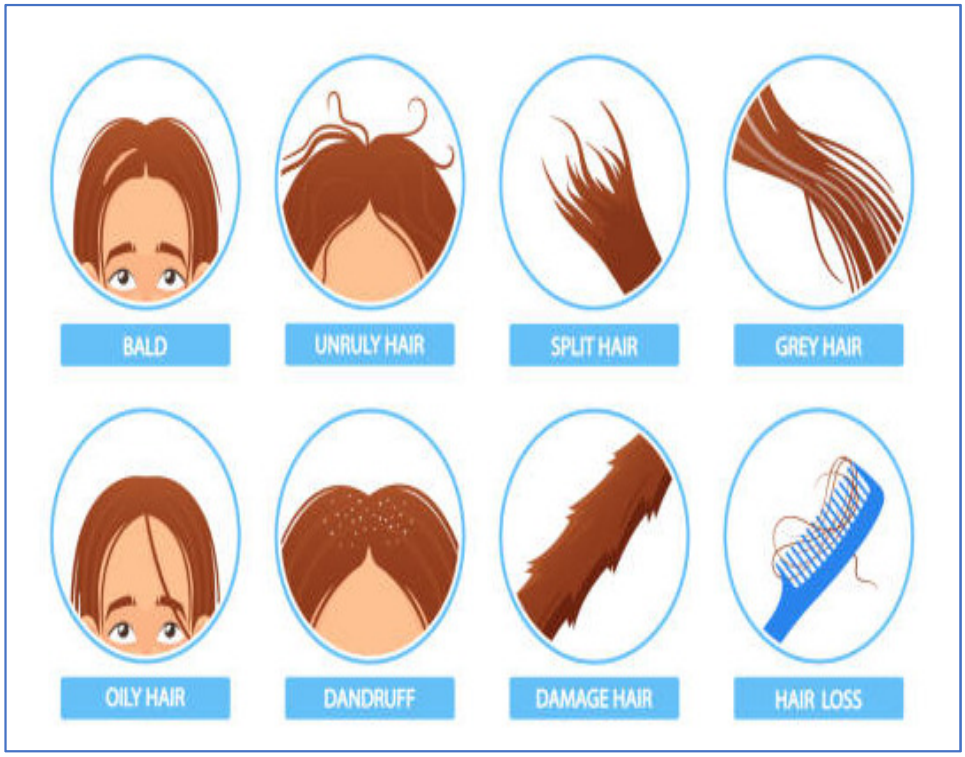


Fig. Hair Problems

Hair Serum:

Hair serums are lightweight hair care products designed to improve hair texture, manageability, and protection against environmental damage. They form a protective barrier around the hair shaft to lock in moisture and prevent external damage. There are different types of hair serums for different hair goals. It is basically a hair care product in liquid form, its consistency thicker than water. Hair serums are enriched with natural oils and plant extracts to offer additional nourishment and treatment benefits.

History of Hair Serum:

1. Traditional Origins (Ancient Times – 19th Century):

- Even though hair serum as a product is modern, its concept originates from ancient hair care practices.
- In Ayurveda, Traditional Chinese Medicine, and Egyptian cultures, people used herbal oils like:
- Coconut oil, amla oil, castor oil, sesame oil, bhringraj, etc.
- These natural treatments were used to add shine, reduce dryness, strengthen hair, and maintain scalp health — similar goals as modern serums.

2. Evolution of Cosmetic Science (Early 1900s – 1970s):

- The 20th century saw the rise of shampoos and conditioners, but there was no specific product for shine, frizz-control, or hair protection.
- In the 1960s and 70s, with the development of synthetic ingredients like silicones and polymers, a new kind of product started forming — the early version of hair serum.

3. Invention of Hair Serum (1980s):

- Hair serum was first introduced in the 1980s, focusing on frizz control, shine, and smoothness.
- The first popular serum was "Frizz-Ease Hair Serum" by John Frieda, launched in 1989.
- These serums were silicone-based, using ingredients like dimethicone and cyclomethicone, which created a smooth coating on the hair, sealing moisture and giving instant shine.

4. Rise in Popularity (1990s – 2010s):

- Hair serums became a regular part of hair care routines, especially for people with frizzy, dry, or heat-styled hair.
- The market expanded with serums offering benefits like:
  - → Heat protection
  - → Colour protection
  - → Split-end repair
  - → Straightening or curl defining
- Ingredients like argan oil, jojoba oil, keratin, vitamin E, and panthenol (B5) became popular in serum formulas.

5. Herbal/Natural Revolution (2010s – Present):

- Recently, there's been a shift towards herbal, organic, and natural hair care.
- Serums now include extracts like onion, aloe vera, neem, hibiscus, bhringraj, amla, and essential oils.
- Consumers demand silicone-free, paraben-free, cruelty-free, and eco-friendly products.

Types of Hair Serum:

❖ **Based on Therapeutic Action:**

1. Frizz-Control Hair Serum:

Purpose: To tame dry, rough, and frizzy hair.

How It Works: Coats the hair strands to reduce friction and lock in moisture, giving smooth and manageable hair.

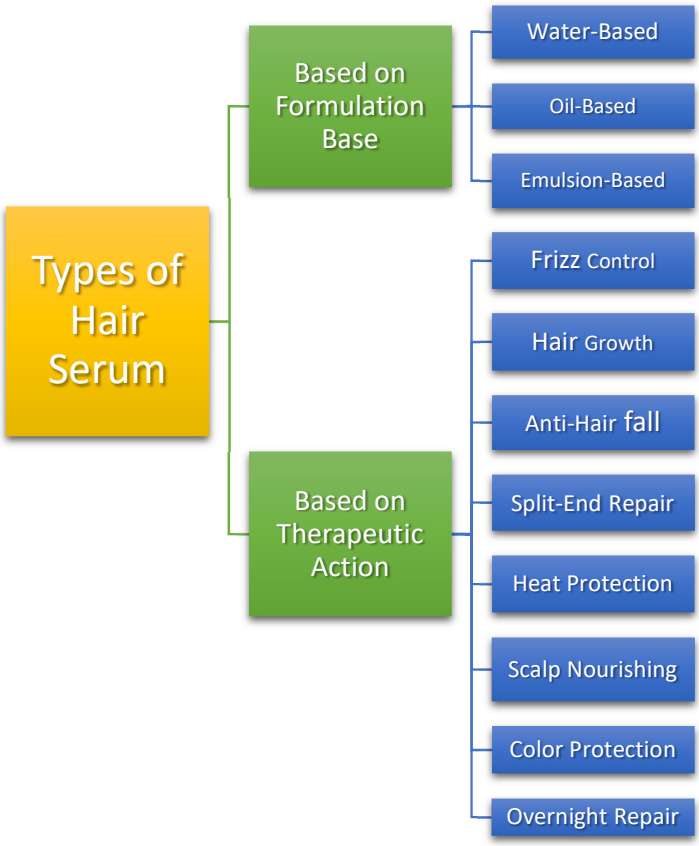
Best For: People with curly, dry, or unmanageable hair; especially in humid climates.

2. Hair Growth Stimulating Serum:

Purpose: To stimulate hair follicles and promote new hair growth.

How It Works: Improves blood circulation in the scalp, nourishes follicles, and activates the anagen (growth) phase of hair.

Best For: People with hair thinning, slow hair growth, or early-stage baldness.



3. Anti-Hair Fall Serum:

Purpose: To reduce hair breakage and prevent hair loss.

How It Works: Strengthens the hair shaft, prevents hair damage due to styling or pollution, and reinforces root health.

Best For: People facing seasonal hair fall, stress-related shedding, or post-partum hair loss.

4. Split-End Repair Serum:

Purpose: To seal and repair damaged hair ends.

How It Works: Binds broken cuticles temporarily, smooths out rough ends, and prevents further splitting.

Best For: Chemically-treated or long hair prone to split ends.

5. Heat Protection Serum:

Purpose: To protect hair from damage caused by heat-styling tools (straighteners, curlers, blow dryers).

How It Works: Forms a protective barrier on the hair shaft to minimize direct heat damage and moisture loss.

Best For: Regular users of heat styling tools.

6. Scalp Nourishing Serum (Leave-in Treatment):

Purpose: To treat scalp issues like dandruff, itching, or bacterial infections.

How It Works: Penetrates the scalp, unclogs follicles, reduces inflammation, and kills microbes.

Best For: Dandruff-prone or oily scalp; people with seborrheic dermatitis or itchiness.

7. Colour Protection Serum:

Purpose: To maintain colour vibrancy in dyed or chemically-treated hair.

How It Works: Shields hair from UV damage, reduces oxidation of hair colour, and nourishes chemically stressed strands.

Best For: People who frequently colour or bleach their hair.

8. Overnight Repair Serum:

Purpose: Deep nourishment and repair while sleeping.

How It Works: Penetrates deeper layers of hair overnight, repairing damage and hydrating intensely.

Best For: Damaged, dry, or lifeless hair needing deep conditioning.

❖ **Based on Formulation Base:**

1. Water-Based Hair Serum:

Description: These serums have a water or hydrosol base and are usually light-weight, non-greasy, and fast-absorbing.

Texture: Thin, liquid, and often transparent.

Best For: Oily scalp, fine or thin hair, people who don't want a sticky feel.

Benefits:

1. Hydrates hair without heaviness
2. Can be used as leave-in
3. Great for daily use
4. Doesn't weigh down the hair

2. Oil-Based Hair Serum:

Description: These serums are oil-rich and provide deep nourishment and shine. They're slightly heavier and stay longer on hair strands.

Texture: Thick or semi-thick, glossy, and smooth.

Best For: Dry, frizzy, damaged, or chemically-treated hair.

Benefits:

1. Deeply nourishes and strengthens hair
2. Adds shine and smoothness
3. Prevents breakage and split ends
4. Seals moisture

3. Emulsion-Based (Water + Oil Mix) Hair Serum:

Description: These are a blend of water and oil phases, stabilized by emulsifiers. They give balanced hydration and nourishment.

Texture: Milky or creamy texture, medium weight.
Best For: Normal to combination hair, scalp and strand care.
Benefits:

1. Hydration + oil nourishment
2. Lightweight conditioning
3. Easy absorption without greasiness

How to Apply Serum:

Step 1: Clean Your Scalp and Hair:

- Wash your hair with a mild herbal or sulphate-free shampoo to remove dirt, oil, and buildup.
- Gently towel-dry your hair.
- Hair should be slightly damp for better absorption.

Step 2: Part Your Hair into Sections:

- Use a comb or your fingers to divide your hair into small section.
- This allows better access to the scalp, where the serum needs to be applied.

Step 3: Take a Small Amount of Serum:

- Shake the bottle well if needed.
- Take 1–2 ml of serum using a dropper or your fingertips.
- If using a spray bottle, 5–6 sprays are usually enough to cover the scalp.

Step 4: Directly apply on the Scalp:

- Apply the serum directly onto the scalp, especially in thinning or balding areas.
- Gently press or tap it into the skin.
- Do not apply on hair strands, as this type of serum targets the roots.

Step 5: Massage the Scalp Gently:

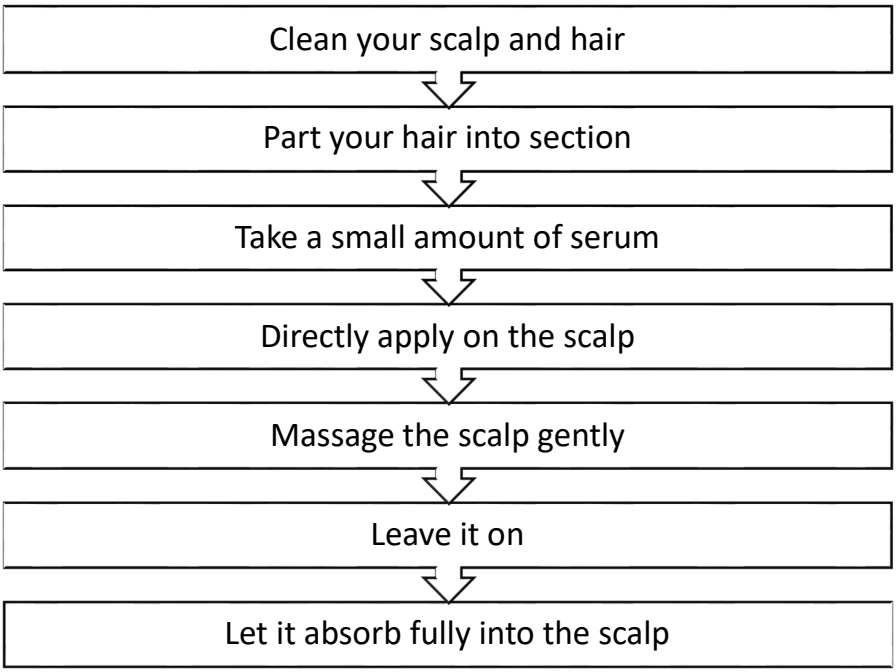
- Use your fingertips to massage in circular motions for 3–5 minutes.
- This improves blood circulation and helps serum penetrate into the hair follicles.

Step 6: Leave it on:

- Do Not Rinse
- Let it absorb fully into the scalp.

Step 7: Apply Consistently:

- Use the serum once or twice daily for best results—morning and night.
- Hair growth results usually appear after 4–8 weeks of regular use.



Benefits of Hair Serum:

1. Controls Frizz
   - → Hair serum forms a protective layer over the hair strands.
   - → It locks in moisture and shields hair from humidity.
   - → This helps in taming dry, rough, and frizzy hair, making it smoother.

2. Adds Shine and Gloss
   - → Most serums contain oils or light-reflecting ingredients.
   - → They instantly enhance the natural shine of your hair, making it look healthy and glossy.

3. Detangles Hair
   - → Serum smoothens the surface of the hair, reducing knots and tangles.
   - → It makes combing easier and prevents breakage caused by pulling.

4. Protects from Heat Damage
   - → Acts as a barrier against high temperatures from styling tools like straighteners, curlers, or blow dryers.
   - → Prevents hair from becoming dry or burnt due to excessive heat.

5. Prevents Split Ends
   - → Coats the hair shaft and temporarily seals split ends.
   - → Reduces the appearance of damaged hair and keeps ends looking healthier.

6. Moisturizes and Hydrates
   - → Herbal serums often contain aloe vera, glycerine, or natural oils.
   - → These ingredients deeply moisturize dry, brittle hair and restore softness.

7. Reduces Hair Fall
   - → Less breakage due to smooth combing and detangling.
   - → Some herbal serums contain ingredients like amla or bhringraj that strengthen hair roots and reduce hair fall from the scalp.

8. Treats Scalp Issues
   - → Tea tree, neem, or Tulsi-based serums can reduce dandruff, itching, and scalp infections.
   - → These herbal extracts have antibacterial and antifungal properties.

9. Improves Hair Texture
   - → Regular use of serum improves hair quality, making it soft, smooth, and silky over time.
   - → Helps repair damaged or chemically treated hair.

10. Boosts Hair Growth
   - → Serums with rosemary, onion extract, or bhringraj help stimulate blood circulation in the scalp.
   - → Promotes new hair growth and improves hair density in the long run.

<u>Need of Hair Serum</u>:

1. Moisture & Hydration:
- Provides essential moisture to dry, brittle hair, especially after heat styling or chemical treatments.
- Helps retain moisture in the hair shaft, preventing dehydration.

2. Frizz Control:
- Controls frizz and flyaway caused by humidity or dryness.
- Ideal for those with curly or unruly hair.

3. Shine & Lustre:
- Adds an instant glossy, healthy shine to dull and lifeless hair.
- Makes hair look polished and vibrant.

4. Protects from Heat Damage:
- Shields hair from the damaging effects of heat styling tools like straighteners, blow dryers, and curling irons.
- Prevents split ends and breakage caused by excessive heat exposure.

5. Reduces Hair Fall:
- Strengthens hair and reduces breakage during brushing or combing.
- Some herbal serums provide nourishment to the scalp, which may help reduce hair fall.

6. Detangling:
- Makes hair softer and more manageable, making it easier to detangle.
- Reduces pulling and breakage during combing.

Function of Hair Serum:

1. Smoothens the Hair Shaft:
- Hair serum coats the hair cuticle, sealing it and making the hair smooth and shiny.

2. Repairs Damage:
- Contains ingredients like vitamins and oils that repair hair damage caused by styling, sun exposure, or pollution.
- Helps in temporarily sealing split ends and reducing the appearance of damage.

3. Adds Protection:
- Acts as a protective barrier, shielding hair from environmental factors like UV rays, pollution, and humidity.

4. Improves Hair Manageability:
- Softens the hair, making it easier to style or comb without tugging.
- Reduces static and flyaway, providing a sleeker appearance.

5. Boosts Hair Growth:
- Some hair serums are formulated with growth-boosting ingredients (e.g., rosemary, amla, bhringraj) that stimulate the scalp and promote hair growth.

Do's	Don'ts
Start with small amount	**Overapply Serum**
Apply to damp and clean hair	**Apply to dry or unwashed hair**
Focus on hair length and scalp	**Rinse it out**

Table: Do's and Don'ts

Collection of Plant Parts:

1. Collection of Hibiscus Flowers (Hibiscus rosa-sinensis):

- **Best Time to Collect:**
  Early morning when flowers are fresh and fully bloomed.
  Avoid collecting during rain or high humidity.
- **How to Collect:**
  Use clean scissors or hand-pick the flowers gently.
  Choose only healthy, bright-coloured and fully opened flowers.
  Avoid wilted or insect-damaged ones.
- **Post-Collection Handling:**
  Spread the flowers on a clean muslin cloth or tray in shade for drying if needed.
  Avoid direct sunlight to retain colour and phytochemical content.
  Store in airtight containers in a cool, dry place.

2. Collection of Neem Bark (Azadirachta indica):

- **Best Time to Collect:**
  Preferably during the dry season when the tree is not actively flowering or fruiting (usually late winter to early summer).
- **How to Collect:**
  Select mature trees (5+ years old).
  Remove thin outer bark with a sterilized knife from branches or fallen logs — do not damage the main trunk.
  Cut in small strips or chips.
- **Post-Collection Handling:**
  Wash to remove dust or debris if needed, then dry in shade or low heat.
  Store in sealed containers, away from moisture.

3. Collection of Aloe Vera (Aloe barbadensis miller):

- **Best Time to Collect:**
  Early morning or evening — avoid intense sunlight.
  Choose mature leaves from plants that are 1.5 to 2 years old.
- **How to Collect:**
  Cut thick, outermost leaves from the base using a sterilized knife.
  Allow the yellow latex (aloin) to drain out — it's irritating and usually discarded unless used intentionally.
- **Post-Collection Handling:**
  Wash thoroughly.
  For gel: peel and extract the clear inner gel; use immediately or preserve under refrigeration.
  For powder: dry the gel at low temperature and powder it.

4. Collection of Hibiscus Leaves:

- **Best Time to Collect:**
  During early morning in dry weather.
  Best when the plant is mature and healthy, usually in the growing season.
- **How to Collect:**
  Pluck young but fully developed leaves from disease-free plants.
  Avoid yellow or insect-damaged leaves.
- **Post-Collection Handling:**

Rinse gently to remove dust.
Dry in shade or use a dehydrator below 40°C.
Store in airtight containers in a cool, dark place.

5. Collection of Mulethi (Liquorice Root – Glycyrrhiza glabra):

- **Best Time to Collect:**
  Roots are usually harvested in late autumn or winter, 2-3 years after planting.

- **How to Collect:**
  Carefully dig around the plant to extract roots without breaking.
  Select thick, firm, healthy roots.
- **Post-Collection Handling:**
  Wash off soil, slice into thin pieces.
  Dry in shade or in a drying oven at 40–50°C.
  Store in sealed containers away from light and humidity.

2. MATERIAL AND METHODOLOGY

Ingredients of hair serum

1) Hibiscus flowers extract
2) Hibiscus leaves extract
3) Neem bark extract
4) Mulethi extract
5) Aloe vera gel
6) Pudina oil
7) Glycerine
8) Vitamin E capsule
9) Rose water
10) Distilled water

Pharmacogenetic data of the following:

- ***Hibiscus***

- **Biological source**: Hibiscus is the dried or fresh flowers, leaves, roots, and stem of the plant Hibiscus rosa-sinensis.

- **Scientific Name:** *Hibiscus rosa-sinensis* L.
- **Family:** Malvaceae.
- **Part which can be Used:**
  - Flowers,
  - Leaves,
  - Roots, and
  - Stem.

- **Origin:** Native to tropical and subtropical regions, especially Asia and the Pacific Islands.

Fig. Hibiscus plant

Morphological Description:

- Habit: Evergreen shrub or small tree
- Leaves: Simple, alternate, ovate, serrated margins, dark green
- Flowers: Large, bright red, pink, yellow, or white, funnel-shaped, five-petaled
- Stem: Woody, brown, branched
- Roots: Fibrous root system

Microscopical Characters:

- Leaf:
  - Dorsiventral structure with prominent palisade parenchyma
  - Anisocytic stomata on the lower epidermis
  - Mucilage cells and calcium oxalate crystals present
  - Non-glandular trichomes
- Stem:
  - Collenchymatous hypodermis
  - Secondary xylem and phloem well developed
  - Pith with parenchymatous cells
- Flower:
  - Multicellular epidermal hairs on petals
  - Vascular bundles in petals

Chemical Constituents:

- Flavonoids
  - Quercetin
  - Kaempferol
  - Myricetin
- Anthocyanins (responsible for flower colour)
  - Cyanidin-3,5-diglucoside
  - Delphinidin
  - Cyanidin-3-sophoroside
- Tannins
  - Catechins
  - Ellagitannins
- Alkaloids
  - Hibiscetin
- Saponins
  - Natural surfactant compounds
- Mucilage
  - Polysaccharides contributing to its emollient properties
- Fatty Acids (in seeds)
  - Linoleic acid
  - Oleic acid
  - Palmitic acid
- Steroids and Terpenoids
  - β-sitosterol
  - Stigmasterol
- Ascorbic Acid (Vitamin C)
  - Antioxidant present in flowers and leaves

➢ ***Neem***

Biological Source:
Neem consists of the dried or fresh leaves, bark, seeds, flowers, and oil obtained from the plant Azadirachta indica.

Fig. Neem Tree

Scientific Name: Azadirachta indica A. Juss.

Family: Meliaceae

Part which can be used:
- Leaves
- Bark
- Seeds
- Flowers
- Fruits
- Neem oil (from seeds)

Origin & Distribution:
- Native to India, Myanmar, Sri Lanka, and Bangladesh
- Widely cultivated in tropical and subtropical regions around the world.

Morphological Description:
- Habit: Large, evergreen or semi-evergreen tree, up to 15–20 meters tall
- Leaves: Alternate, pinnately compound with 8–19 serrated leaflets, bright green
- Flowers: Small, white, fragrant, arranged in axillary panicles
- Fruits: Small, oval to oblong drupe, initially green, turns yellow on ripening
- Bark: Hard, rough, brownish-grey with deep fissures
- Seeds: Kernel contains high oil content

Microscopical Characters:
- Leaf:
  - Dorsiventral structure with a well-developed palisade layer

  - Anisocytic stomata (irregularly arranged) on both surfaces
  - Presence of oil glands and calcium oxalate crystals
- Bark:
  - Parenchymatous cortex with secretory canals
  - Lignified sclerenchymatous fibres in secondary phloem
- Seeds:
  - Endosperm rich in oil globules
  - Presence of aleurone grains

Chemical Constituents:

- Limonoids (Tetranortriterpenoids):
  - Azadirachtin (major bioactive compound)
  - Nimbin
  - Nimbidin
  - Salannin
- Flavonoids:
  - Quercetin
  - Kaempferol
- Tannins:
  - Catechins
  - Gallic acid
- Saponins
- Alkaloids
- Fatty Acids (in Neem Oil):
  - Oleic acid
  - Linoleic acid
  - Stearic acid

➢ ***Mulethi***

Fig. Mulethi

Biological Source:
Mulethi consists of the dried roots and stolons of Glycyrrhiza glabra.

Scientific Name:
Glycyrrhiza glabra

Family:
Fabaceae (Leguminosae)

Part which can be used:
- Dried roots and stolons

Origin:
Native to the Mediterranean regions, parts of Asia, and Southern Europe. Cultivated in India, China, Iran, and Afghanistan.

Morphological Description:
Roots are cylindrical, slightly branched, about 20–30 cm long and 0.5–2 cm in diameter. Outer surface is brownish-yellow, inner surface is yellow. Fracture is fibrous and tough. Characteristic odor and sweet taste due to glycyrrhizin.

Microscopical Characters:
Thin-walled, polygonal cork cells. Parenchymatous cortex with scattered prismatic calcium oxalate crystals. Multiseriate medullary rays, sclerenchymatous fibers, oval/rounded starch grains, and laticiferous tissues present.

Chemical Constituents:
- Triterpenoid Saponins:
  - Glycyrrhizin
- Flavonoids:
  - Liquiritin
  - Isoliquiritin
  - Glabridin
  - Licochalcone A
- Coumarins:
  - Herniarin
  - Umbelliferone
- Polysaccharides:
  - Starch
  - Gum
- Others:
  - Resin
  - Tannin
  - Volatile oil
  - Protein
  - Asparagine

➢ ***Aloe vera***

Fig. Aloe Vera

Biological Source:
Aloe vera consists of the mucilage obtained from the parenchymatous cells of the leaves of *Aloe barbadensis Mill.*

Scientific Name:
Aloe barbadensis Mill.

Family:
Liliaceae (Now updated to Asphodelaceae)

Part which can be used:
Fresh leaves (gel and latex)

Origin:
Native to North Africa, but cultivated widely in India, China, USA, and tropical regions.

Morphological Description:
Leaves are thick, fleshy, green, lanceolate, 30–60 cm long with serrated margins. The surface is smooth and covered with a waxy cuticle. Gel is present inside the leaf pulp.

Microscopical Characters:

- Epidermis: Covered with thick cuticle
- Mesophyll: Contains large mucilage-containing parenchyma cells
- Vascular bundles: Collateral and surrounded by bundle sheath
- Calcium oxalate crystals: Present as acicular needles
- Pericyclic fibers: Present
- Gel region shows mucilage cells with cellulosic walls

Chemical Constituents:
Anthraquinone Glycosides:

- Aloin A
- Aloin B

Chromones:

- Aloesin

- Aloeresin A

Polysaccharides:

- Acemannan
- Glucomannan

Enzymes:

- Amylase
- Catalase
- Cellulase

Others:

- Vitamins (A, C, E, B12)
- Minerals (calcium, magnesium, zinc)
- Saponins
- Sterols (lupeol, campesterol, β-sitosterol)

➢ ***Pudina***

Biological Source:
Mentha consists of the aerial parts of *Mentha arvensis* and other species of *Mentha*.

Scientific Name: Mentha arvensis Linn. (Commonly used)
Other species: Mentha piperita, Mentha spicata

Family:
Lamiaceae (Labiatae)

Part which can be used:
Leaves and flowering tops

Fig. Pudina leaves

Origin:
Native to Europe and Asia. Extensively cultivated in India, Japan, and the USA.

Morphological Description:
Herbaceous plant, 30–60 cm tall, quadrangular stem, opposite leaves, serrated margin, green colour, characteristic minty aroma. Leaves are ovate to lanceolate.

Microscopical Characters:

- Glandular trichomes: Present (capitate and peltate)
- Epidermis: Uniseriate with multicellular covering hairs
- Stomata: Diacytic
- Collenchyma: Below epidermis
- Vascular bundles: Collateral
- Oil glands: Contain essential oil

Chemical Constituents:
Volatile Oils:

- Menthol
- Menthone
- Menthyl acetate
- Pulegone
- Cineole

Flavonoids:

- Luteolin
- Apigenin

Tannins, Resins, Bitter principles

➢ ***Glycerine***

Biological Source:
Glycerine is obtained as a by-product during the saponification (hydrolysis) of fats and oils of both **animal and vegetable** origin.

Fig. Glycerine

Scientific Name:
Glycerol (IUPAC: Propane-1,2,3-triol)

Family:
(Not applicable – it's a chemical compound, not a plant)

Parts which can be used:
(Not applicable – extracted from oils/fats)

Origin:
Derived from hydrolysis of natural fats and oils; also synthesized from **propylene** in petroleum industry.

Morphological Description:
Clear, colourless, odourless, syrupy liquid. Sweet in taste. Miscible with water and alcohol.

Microscopical Characters:
(Not applicable – it's a pure liquid, no plant tissue)

Chemical Constituents:
Main component:

- Glycerol ($C_3H_8O_3$)

Other info:

- No active constituents – it's used as a solvent, humectant, sweetening agent, and emollient.

➢ **Vitamin E**
Biological Source:
Vitamin E is obtained from natural sources like **wheat germ oil, sunflower oil, almonds, spinach, and vegetable oils**.

Scientific Name:
Tocopherol (mainly **α-Tocopherol** is biologically active)

Family:
(Not applicable – it's a **nutrient**, not a plant)

Parts which can be used:
Oil extracted from seeds and nuts

Origin:
Naturally occurs in **plant-based oils, nuts, seeds, and green leafy vegetables.**

Morphological Description:
Yellow to amber-coloured viscous oil. Odourless, tasteless, and soluble in fats and oils. Insoluble in water.

Fig. Vitamin E capsule

Microscopical Characters:
(Not applicable – pure compound)

Chemical Constituents:

- **α-Tocopherol**
- **β-Tocopherol**
- **γ-Tocopherol**
- **δ-Tocopherol**

➢ ***Rose***

Biological Source:
Rose water is obtained by **steam distillation of the fresh petals** of *Rosa damascena* and other Rosa species.

Scientific Name:
Rosa damascena Mill.

Family:
Rosaceae

Fig. Rose water

Parts which can be used:
Fresh petals

Origin:
Native to Middle East and Central Asia; widely cultivated in **India (especially in Kannauj), Iran, Bulgaria, and Turkey**

Morphological Description:
Clear, colourless liquid with a characteristic rose-like Odor. Slightly acidic. Miscible with water and alcohol.

Microscopical Characters:
(Not applicable – it's a distilled liquid)

Chemical Constituents:
Volatile Compounds:

- Citronellol
- Geraniol
- Nerol
- Phenyl ethyl alcohol
- Linalool

Others:

- Trace amounts of tannins and flavonoids

3. Methodology:

1. Objective:

To formulate a water-based herbal hair serum using natural ingredients like Hibiscus, Neem, Mulethi, Pudina oil, Vitamin E, and a natural gelling agent.

2. Required Materials & Equipment:

- Hibiscus petals (dried) - 12 g
- Hibiscus Leaves (dried) -12 g
- Neem bark (coarsely powdered) - 12 g
- Mulethi root (coarsely powdered) - 12 g
- Water (for decoction) - 240 mL
- Aloe vera gel (as gelling agent) - 2.4 g
- Rose water / Distilled water - 40 mL
- Pudina oil (Mentha extract) - 2.4 mL
- Vitamin E (400 IU) - 2 capsules (approx. 2 mL)
- Rose water - q.s. to make 120 Ml

Equipment:

- Beakers, measuring cylinders
- Mortar and pestle
- Hot plate or heating mantle
- Filter paper
- Magnetic stirrer or glass rod
- Weighing balance

3. Procedure:

A. Preparation of Herbal Extract (Kwatha):

- Weigh 12 g each of hibiscus petals, neem bark, and mulethi.
- Add the herbal materials to 240 mL distilled water in a beaker.
- Boil the mixture gently until the volume reduces to one-fourth (approx. 60 mL).
- Filter the extract using muslin cloth to remove coarse particles.
- Allow the filtrate to cool to room temperature

Herbal Ingredients	Quantity(dry) (g)	Amount of water in (ml)	Reduced Amount(decoction) (ml)	Boiling Time (Approx)	Cooling Time (Approx)
Hibiscus petals	12	96	~24	25-30 Min	10-15 Min
Hibiscus Leaves	12	96	~24	25-30 Min	10-15 Min
Neem bark	12	96	~24	25-30 Min	10-15 Min
Mulethi	12	96	~24	25-30 Min	10-15 Min

Table A – Quantity and time required for production of decoction

B. Preparation of Gel Base:

- Take 2.4 g xanthan gum (or aloe vera gel) in a beaker.
- Gradually add 40 mL of rose water with continuous stirring.
- Allow the gel to hydrate completely (30–45 min).

C. Final Formulation:

- Add the cooled herbal decoction (60 mL) to the gel base with gentle stirring.
- Add 2.4 mL pudina oil dropwise while stirring to ensure uniform mixing.
- Squeeze out contents of 2 Vitamin E capsules into the mixture.
- Add 0.24 g sodium benzoate as preservative.
- Add rose water to make the final volume up to 120 mL.
- Stir thoroughly until a uniform, translucent serum is formed.

4. Packaging:

- Transfer the prepared serum into sterilized amber-coloured glass or PET bottles.
- Label with batch number, date of manufacture, and storage instructions.

Formulation Table:

SR. NO.	Ingredients	Required quantity		Role of Ingredients
		(g)	ml	
1	Hibiscus flower extract	12	~24	Promotes Hair Growth and adds shine
2	Hibiscus leaves extract	12	~24	Strengthens roots and conditions scalp
3	Neem bark extract	12	~24	Prevents dandruff and scalp infections
4	Mulethi Extract	12	~24	Soothes scalp and nourishes hair
5	Aloe vera gel	2.4	2.4	Acts as a hydrating gelling agent
6	Pudina Oil	-	2.4	Provides cooling and improves circulation
7	Glycerine	-	3	Retains moisture and prevents frizz
8	Vitamin E Capsule	-	~2	Protects hair from oxidative damage
9	Rose water	-	q. s	Adds fragrance and soothes scalp
10	Distilled water	-	q. s	Acts as a safe base for dilution

Table B – Quantity and role of ingredients

Preliminary phytochemical Test:

The aqueous extracts of Neem bark, Hibiscus flower, Hibiscus leaves, and Mulethi root were subjected to standard phytochemical tests to detect the presence of various secondary metabolites using the following procedures:

1)Test for Alkaloids (Mayer's Test)
Procedure: 2 ml of extract was acidified with dilute HCl and a few drops of Mayer's reagent were added.
Observation: Formation of a white or creamy precipitate indicates the presence of alkaloids.

2)Test for Flavonoids (Shinoda Test)
Procedure: To 2 ml of extract, a small piece of magnesium ribbon and 2 drops of concentrated HCl were added.
Observation: Development of pink or reddish color indicates the presence of flavonoids.

3)Test for Tannins (Ferric Chloride Test)
Procedure: 2 ml of extract was treated with a few drops of 5% ferric chloride solution.
Observation: Formation of blue-black or greenish-black color indicates the presence of tannins.

4)Test for Saponins (Foam Test)
Procedure: 5 ml of extract was vigorously shaken with water in a test tube.
Observation: Persistent froth formation indicates the presence of saponins.

5)Test for Glycosides (Keller-Killiani Test)
Procedure: 2 ml of extract was treated with 1 ml of glacial acetic acid, a drop of ferric chloride, and concentrated sulfuric acid was added carefully.
Observation: Formation of a reddish-brown ring at the junction indicates the presence of cardiac glycosides.

6)Test for Terpenoids (Salkowski Test)
Procedure: 2 ml of extract was mixed with 2 ml of chloroform and 2 ml of concentrated sulfuric acid was carefully added.
Observation: Reddish brown coloration at the interface indicates the presence of terpenoids.

7)Test for Phenols (Ferric Chloride Test)
Procedure: 2 ml of extract was treated with a few drops of neutral ferric chloride solution.
Observation: Formation of blue, green, or violet color indicates the presence of phenols.

8)Test for Proteins (Biuret Test)
Procedure: 2 ml of extract was mixed with 1 ml of 10% NaOH solution and a few drops of 1% copper sulfate solution.
Observation: Appearance of violet or purple color indicates the presence of proteins.

9)Test for Carbohydrates (Molisch's Test)
Procedure: 2 ml of extract was treated with 2 drops of Molisch's reagent, followed by careful addition of concentrated sulfuric acid along the sides of the test tube.
Observation: Formation of a violet ring at the interface indicates the presence of carbohydrates.

3. EVALUATION

The following parameters are used to evaluate the prepared herbal hair serum:

1) ***Physicochemical Evaluation***
   - ❖ pH Measurement
   - ❖ Viscosity Test
   - ❖ Spredability Test
   - ❖ Appearance
   - ❖ Odour
2) ***Skin Irritation Test***
3) ***Performance Test (Efficacy Test)***
   - ❖ Foam test
   - ❖ Hair smoothness and Shine test
   - ❖ Absorption Rate Test

1) PHYSICOCHEMICAL EVALUATION

❖ **pH Measurement:**

✓ Objective:

To determine the pH of the water-based herbal hair serum to ensure it's safe and compatible with the scalp.

Ideal Range: 4.5 – 5.5

✓ Materials Required:

- Calibrated Digital pH Meter
- Beaker (100 mL)
- Glass Stirring Rod
- Distilled Water (for cleaning only)
- Clean Tissue Paper
- Serum Sample (Water-based)

✓ Procedure:

1. Calibrate the pH Meter:
   - Use standard buffer solutions of pH 4.0, 7.0, and 10.0.
   - Rinse the electrode with distilled water before and after calibration.
2. Sample Preparation:
   - Take 10 mL of the water-based herbal serum in a clean 100 mL beaker.
   - No dilution is needed unless the serum is too thick. If so, dilute 1:1 with distilled water.
3. pH Measurement:
   - Immerse the electrode into the serum.
   - Stir gently with a glass rod to avoid air bubbles.
   - Wait until the reading stabilizes (about 30–60 seconds).
   - Record the pH value shown on the display.
4. Post-Measurement:
   - Rinse the electrode with distilled water.
   - Blot gently with tissue to clean and dry.

❖ **Viscosity Test**

✓ Objective:

To determine the viscosity of the formulated herbal hair serum to assess its flow properties and suitability for topical scalp application.

Ideal Range: 100 – 500 cP

✓ Materials Required:

- Brookfield Viscometer (or any rotational viscometer)
- Sample Beaker (100 mL)
- Spindle (Usually spindle No. 2 or 3 for semi-liquid serums)
- Water Bath (optional for temperature control)
- Stopwatch (if using manual method)
- Formulated Hair Serum Sample

✓ Procedure:

1. Sample Preparation:
   - Take about 50 mL of the herbal hair serum in a clean beaker.
   - If needed, equilibrate the sample to room temperature (25 ± 2°C).
2. Instrument Setup:
   - Switch on the Brookfield Viscometer.
   - Choose an appropriate spindle (commonly Spindle No. 2 or 3 for hair serum).
   - Set the spindle speed (e.g., 50 rpm is commonly used for serums).
3. Measurement:
   - Immerse the spindle into the serum until the appropriate immersion depth is reached.
   - Start the viscometer.
   - Allow the reading to stabilize (typically within 30 seconds to 1 minute).
   - Record the viscosity value in centipoise (cP).
4. Cleaning:
   - After measurement, clean the spindle thoroughly with warm water or suitable solvent depending on the formulation.

❖ **Spredability Test:**

Objective:

To evaluate the spreadability of the formulated herbal hair serum to ensure it can be easily applied and uniformly distributed over the scalp.

Ideal Observation: Should spread evenly without resistance.

✓ Materials Required:

- Two glass slides (same size, clean and dry)
- Weight (e.g., 500 g or 1 kg)
- Scale/Ruler (cm)
- Stopwatch
- Herbal Hair Serum Sample

✓ Procedure:

1. Sample Application:
   - Place a fixed amount (e.g., 1 gram) of the hair serum at the center of the lower glass slide.
2. Sandwich Formation:
   - Place the second glass slide over it, so the serum spreads between the two slides.
3. Weight Application:
   - Place a 500 g weight on top of the upper slide.
   - Leave it for 1 minute to allow spreading under pressure.
4. Measurement:
   - Remove the weight and carefully lift the top slide.
   - Measure the diameter (or area) of the spread serum in centimeters using a ruler.

❖ Appearance Test:

✓ Objective:

To observe and document the physical appearance, colour, clarity, consistency, and Odor of the herbal hair serum.

Parameters for Evaluation:

1) Colour: Muddy Green
2) Odour: Minty
3) Clarity: Opaque
4) Consistency: Smooth
5) Phase Inversion: No phase inversion was observed while standing.

✓ Procedure:

1. Visual Inspection: (colour)
   - Pour a small quantity of the serum into a clear glass container.
   - Observe under natural and artificial light.
2. Touch Consistency: (Consistency)
   - Take a drop on your fingertip (using gloves).
   - Assess whether it feels sticky, smooth, greasy, watery, etc.
3. Odor Check:
   - Smell the sample and note the intensity and character of the herbal fragrance.
4. Stability Observation: (Phase inversion)
   - Leave the sample undisturbed at room temperature for 24 hours and observe for any phase separation, sedimentation, or colour change.

2) SKIN IRRITATION TEST

✓ Objective:

To assess the safety of the herbal hair serum by evaluating its potential to cause skin irritation upon topical application.

✓ Materials Required:

- Formulated herbal hair serum
- Sterile cotton swabs or applicators
- Gauze pad
- Alcohol swabs

✓ Procedure:

1. Skin Preparation:
   - Clean a small area on the inner forearm or behind the ear of the volunteer using an alcohol swab.
2. Application:
   - Apply about 0.5 mL of the herbal hair serum using a cotton swab.
   - Cover the area with a gauze pad or micropore tape to prevent rubbing off.
3. Observation Period:
   - Leave the patch for 24 hours.
   - Instruct volunteers not to wash or scratch the area during this period.
4. After 24 Hours:
   - Remove the patch and observe the site for any signs of irritation:
     - Redness
     - Itching
     - Swelling
     - Rash or blister formation

3) PERFORMANCE TEST (EFFICACY TEST)

❖ **Foam Test:**

✓ Objective:

To evaluate the foam-forming ability and stability of the herbal hair serum, which is essential for determining its cleansing and application properties.

✓ Materials Required:

- Test tube or 100 mL graduated cylinder
- Distilled water
- Dropper
- Stop watch
- The formulated herbal hair serum sample

✓ Procedure:

1. Sample Preparation:
   - Take 1 mL of the herbal hair serum in a test tube.
   - Add 10 mL of distilled water to it.
2. Shaking:
   - Shake the test tube vigorously for 10 seconds.
   - Place the tube on the stand and start the stopwatch.
3. Foam Height Measurement:
   - Immediately measure the height of the foam formed (in cm).
   - Note the initial foam height.
4. Foam Stability:
   - Allow the tube to stand undisturbed for 5 minutes.
   - Measure the foam height after 5 minutes.
   - Check if the foam is stable (persistent) or collapses quickly

❖ **Hair smoothness and shine test:**

✓ Objective:

To evaluate the effect of the formulated herbal hair serum on hair texture, smoothness, and shine after application.

✓ Procedure:

1. Pre-treatment:
   - Wash the hair tress with mild shampoo.
   - Rinse thoroughly and towel-dry to damp condition.
2. Application:
   - Apply 1–2 mL of the herbal hair serum evenly to the hair strands.
   - Comb gently to distribute the serum.
3. Observation (After drying naturally):
   - Smoothness: Feel the texture of the treated hair compared to untreated hair.
   - Shine: Observe the hair under a good light source to check gloss and light reflection.

❖ **Absorption Rate Test:**

✓ Objective:

To evaluate the rate at which the herbal hair serum is absorbed into the scalp or hair without leaving behind oily or sticky residues.

✓ Materials Required:

- Clean, washed scalp area
- Timer or stopwatch
- Dropper or pipette
- Tissue paper

✓ Procedure:

1. Pre-treatment:
   - Wash the scalp area (for volunteers) or the hair tress using a mild shampoo and towel-dry gently.
2. Application:
   - Using a dropper, apply 1 mL of the serum to a small section of the scalp or hair tress.
   - Start the stopwatch immediately after application.
3. Observation:
   - Gently spread the serum using fingers or a comb.
   - After 2–5 minutes, press a clean tissue/blotting paper lightly on the area.
4. Result Analysis:
   - If no oil or moisture stain is visible on the tissue, the serum is considered well absorbed.
   - Measure the time taken for complete absorption (when the serum no longer feels wet or greasy).

3. RESULT AND DISCUSSION

1) Preliminary phytochemical Test:

SR. NO.	Phytochemical Test	Neem Bark Extract	Hibiscus Flower Extract	Hibiscus Leaves Extract	Mulethi Root Extract
1	Alkaloids (Mayer's Test)	White ppt	White ppt	White ppt	White ppt
2	Flavonoids (Shinoda Test)	Pink/red colour	Reddish pink	Reddish pink	Magenta colour
3	Tannins (Ferric Chloride Test)	Blue-black ppt	Greenish-black	Greenish-black	Dark green
4	Saponins (Foam Test)	No foam	Stable foam	Stable foam	Persistent foam
5	Glycosides (Keller-Killiani Test)	Reddish brown ring	Reddish brown ring	Reddish brown ring	Reddish brown ring
6	Terpenoids (Salkowski Test)	Reddish brown layer	Reddish brown	Reddish brown	Reddish brown
7	Phenols (Ferric Chloride Test)	Blue/green	Blue	Green	Green
8	Proteins (Biuret Test)	No violet color	Light violet	Light violet	No color
9	Carbohydrates (Molisch's Test)	Violet ring	Violet ring	Violet ring	Violet ring

Fig. Sample for phytochemical test

2) Physicochemical Evaluation:

Sr. No.	Parameter	Test Method	Ideal Observation / Result	Observation / Inference
1	**pH Measurement**	pH paper	Between 4.5 to 6.5 (mildly acidic, scalp-friendly)	**5.0**
2	**Viscosity Test**	Brookfield Viscometer / Glass capillary method	100 – 500 cP	**438.5**
3	**Spreadability Test**	Glass slide method	Spreads easily, diameter > 5 cm under 500g weight	**Good spreadability**
4	**Colour**	Visual inspection	Light pink / green / herbal colour, uniform	**Muddy Green**
5	**Odour**	Organoleptic (by smelling)	Pleasant herbal fragrance, not overpowering	**Minty**
6	**Clarity**	Visual inspection under light	Transparent to slightly hazy, no visible particles	**Opaque**
7	**Consistency**	Touch + visual	Smooth, slightly viscous, non-greasy	**Smooth, slightly viscous, non-greasy.**
8	**Phase Inversion**	Visual check after 24–48 hours at room temperature	No phase separation, stable emulsion	**No Phase Inversion**

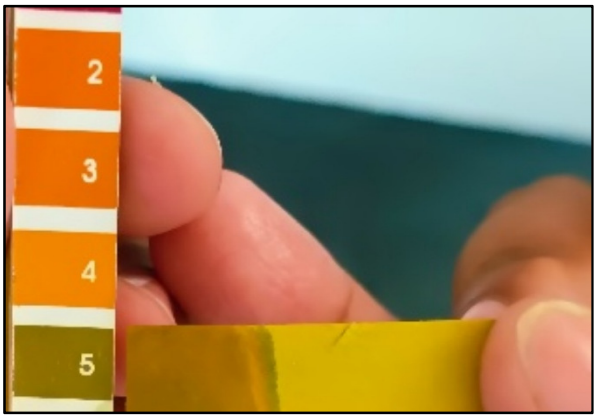


Fig. pH measurement

Fig. Brookfield viscometer

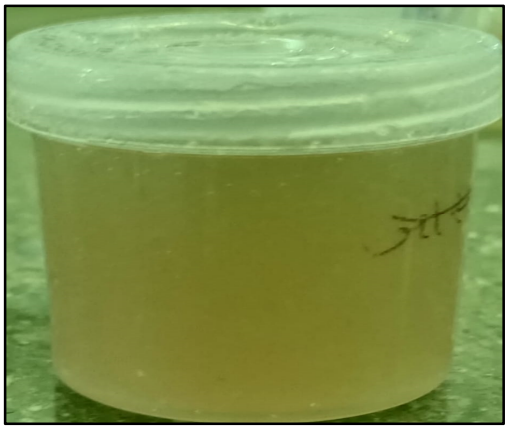


Fig. colour and clarity

Fig. Consistency

3) Skin Irritation Test

Observation	Grade	Reaction	Observation
No change	**0**	**No Irritation**	**Yes**
Slight redness	**1**	**Mild Irritation**	**NO**
Redness + itching	**2**	**Moderate Irritation**	**NO**
Redness + rash or swelling	**3**	**Severe Irritation**	**NO**

4) Performance Test (Efficacy Test):

Sr. No.	Test Method	Ideal Observation	Observation
1	Foam Test	Mild and stable foam formation on shaking	Mild and stable
2	Hair smoothness	Hair feels soft and detangled after application	Soft and easy detangling of hair
3	Shine	Hair appears glossy and healthy under light after application	Shiney hairs
4	Absorption Rate Test	Serum absorbs within 30 seconds to 1 minute without leaving greasy residue	Within 45 – 48 seconds and no greasy feel at all

Fig. Hair smoothness and shine

Fig. Foam Test

Fig. Application of serum to test absorption test

Fig. After 46 - 48 seconds complete Absorption was observed

4. CONCLUSION

The current study focuses on the successful formulation and preliminary evaluation of a water-based herbal hair serum, incorporating multiple medicinal plant extracts and natural ingredients renowned in traditional Indian medicine. The aim was to create a safe, effective, and natural alternative to synthetic hair care products that often come with long-term side effects. The key ingredients used in this formulation were Hibiscus rosa-sinensis (hibiscus), Azadirachta indica (neem bark extract), Mentha arvensis (pudina oil), Glycyrrhiza glabra (mulethi), Vitamin E capsules, a natural gelling agent, and a herbal preservative blend. Each of these ingredients was selected based on their pharmacological significance in scalp and hair health, including antioxidant, anti-inflammatory, antimicrobial, and hair follicle stimulating properties.

The formulation process involved aqueous extraction of herbal actives, careful blending with essential oils, incorporation of Vitamin E for antioxidative protection, and the addition of a gelling agent to ensure proper consistency and ease of application. The product was developed to be lightweight, non-greasy, and rapidly absorbable, aiming to cater to all hair types without leaving residue or oiliness. The final formulation was subjected to various physicochemical evaluations, such as pH (which was maintained around the natural scalp range of 5.5–6.5), viscosity (ensuring easy spreadability), organoleptic properties (appearance, colour, and aroma), and microbial stability (no contamination under storage conditions).

The results of these tests confirmed that the serum maintained the stability over a defined period and showed no visible microbial growth, phase separation, or changes in colour, texture, or odour. Moreover, the serum demonstrated excellent cosmetic acceptability in terms of texture, ease of application, and herbal fragrance. Its natural composition makes it suitable for individuals with sensitive scalps or those looking for chemical-free alternatives in hair care. The synergy between traditional knowledge and modern pharmaceutical techniques is clearly evident in the formulation's efficacy and user-friendly characteristics.

Furthermore, this study highlights the rising global demand for herbal and ayurvedic cosmetic products, which are perceived as more sustainable, biodegradable, and safer for long-term use. The use of well-known herbs like hibiscus for hair strengthening and regrowth, neem for dandruff and scalp cleansing, pudina for cooling and blood circulation, and mulethi for soothing inflammation enhances the product’s therapeutic value. Vitamin E contributes as an antioxidant and hair conditioner, while the use of natural preservatives ensures shelf-stability without resorting to synthetic parabens or sulphates.

In conclusion, the formulated herbal hair serum successfully integrates pharmacognostic wisdom with cosmeceutical formulation science to offer a safe, stable, and effective product. It provides a promising herbal alternative to chemical-laden commercial serums and supports the idea of returning to nature-inspired formulations. Further work such as in vivo efficacy studies, dermatological testing, consumer satisfaction trials, and pilot-scale production will help to validate its clinical performance and commercial potential. With the growing shift toward herbal personal care, this formulation aligns well with market trends and consumer expectations in the cosmetic industry.

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