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Nano Herbal Hair Spray: A Synergistic Blend for Hair care

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ABSTRACT

Studies of herbal formulations have picked up the pace with an escalating demand for natural, preservative-free shampoos for hair care. The present investigation is focused on the formulation and evaluation of a nano-herbal hair spray with anti-dandruff properties, hair strength, and scalp nourishment via chitosan nanoparticles along with herbal extracts. Neem, fenugreek, and amla have been chosen with their established antifungal activity, antioxidant values, and capacity to strengthen the hair.

The herbal extracts were blended with a sprayable product using chitosan nanoparticles for improving ingredient stability, bioavailability, and antimicrobial preservation. Phytochemical analysis was done to ascertain the presence of primary active components. The formulation was tested for properties like pH, viscosity, sprayability, and microbiological resistance to evaluate stability and efficacy. The enhancing activity of chitosan nanoparticles towards bioavailability and providing antibacterial protection was also studied. To determine the impact of the hair spray on hair elasticity and resistance to breakage, tensile strength tests were carried out on hair samples.

Phytochemical screening validated the presence of alkaloids, flavonoids, tannins, and saponins, which are responsible for the therapeutic effectiveness of the spray. Stability studies proved that the formulation retained uniform pH, microbial resistance, and viscosity over time without the need for synthetic stabilizers. Chitosan nanoparticles added to greater antibacterial protection and better penetration of ingredients. Hair tensile strength tests showed that daily use of the nano-herbal hair spray significantly enhanced elasticity and breakage resistance.

These results show that the nano-herbal hair spray is a worthwhile and effective natural alternative to traditional cosmetic hair treatment products. The chitosan-strengthened formula provides a bioactive-high, non-greasy, and effortless-to-apply product that aids scalp nutrition and enhances healthier and stronger hair. Future studies will emphasize large-scale usage testing and longer clinical trials to substantiate its effectiveness and cost benefits.

Keywords: Chitosan Nanoparticles, Herbal Extracts, Nano Herbal Hair Spray, Hair Strengthening, Anti-dandruff

1. INTRODUCTION

The last few years have witnessed a substantial increase in demand for personal care products based on herbal and natural ingredients. Among them, hair care products have garnered increased interest, especially in managing scalp disorders like dandruff, dryness, hair loss, and microbial infection [1,2].

Traditional hair care products tend to employ synthetic chemicals, which might provide temporary effects but carry long-term hazards like scalp sensitivity, endocrine disturbance, and environmental pollution [3]. This transition to herbal hair care is driven by growing consumer interest and a renewed interest in traditional systems of medicine such as Ayurveda and naturopathy [1,4]. Our present formulation—a herbal hair spray—is a contemporary delivery system for timeless knowledge. It is formulated as a non-oily, leave-in spray infused with plant extracts and bioactive ingredients that address scalp health, follicle care, and microbiome balance [2,5].

The active phytoconstituents are Neem, Amla, Fenugreek, Hibiscus, and Aloe Vera, all of which are reported to have scalp-soothing, antimicrobial, antioxidant, and hair-strengthening properties [6,10]. The addition of essential oils like Tea Tree, Lavender, and Rosemary adds to the therapeutic value [11,12]. For better absorption and efficacy, chitosan nanoparticles are added, providing controlled release and penetration into deeper follicles [13,15].

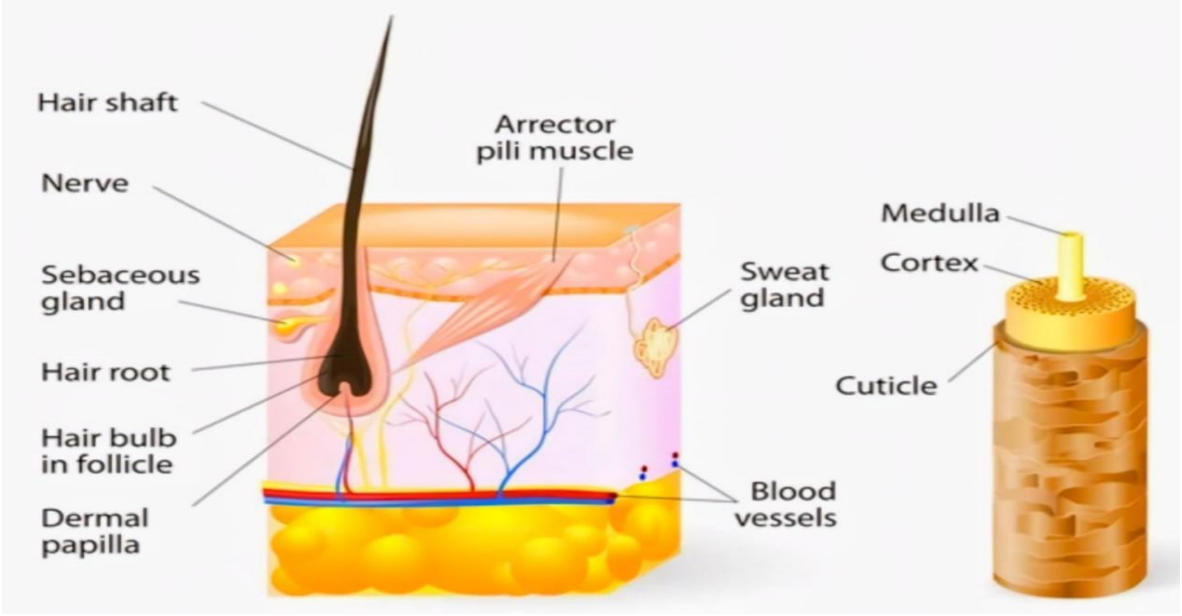
This composition not only addresses functional scalp care but also encourages overall hair health, presenting a complete hair care solution for those looking for natural, long-lasting, and effective hair treatment [2,4].

1.1 BASIC PHYSIOLOGY OF THE HAIR & SCALP

Scalp and hair follicles in combination create a sensitive, interconnected system that is essential for healthy hair growth and maintenance [16,17]. Scalp consists of several layers—epidermis, dermis, and subcutaneous tissue—each serving to support the hair follicles present within.

Structure of Hair:

Hair itself is constituted mainly of keratin, a fibrous protein produced by keratinocytes in the hair matrix. Each hair grows out of a hair follicle, which is embedded deep within the dermis and is enveloped by sebaceous glands, capillaries, and nerve endings [17].



[Figure: 1- Structure of Hair]

The hair follicle consists of the following components:

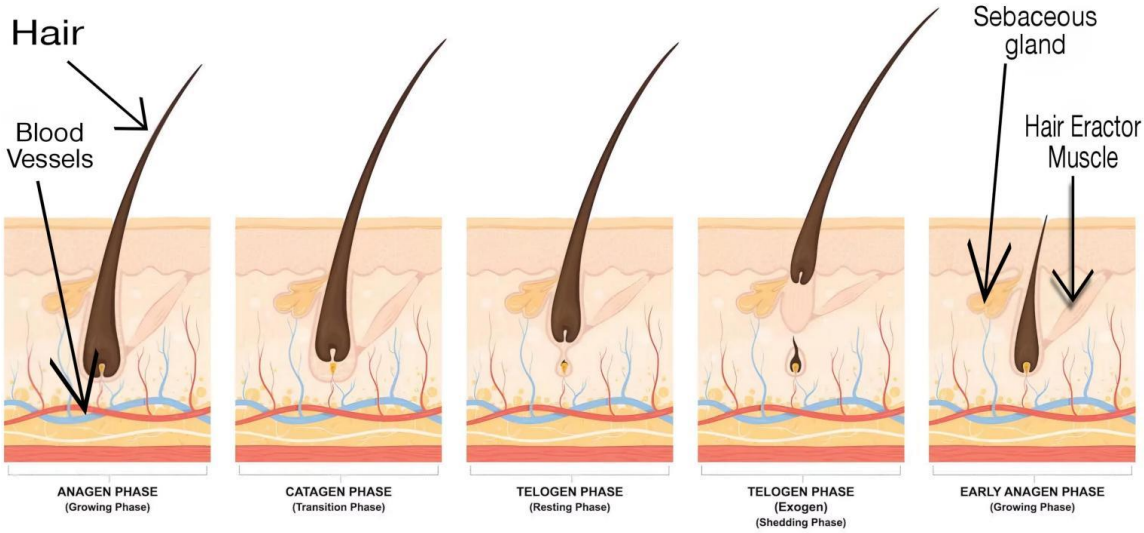
- Hair Shaft: The portion of hair that is seen above the scalp and constitutes the:

- Cuticle (outermost protective layer),
- Cortex (bulk of the hair, highly pigmented and structural protein rich),
- Medulla (innermost layer, found in thicker hair).

Hair Root: Projects into the dermis and has the hair bulb, dermal papilla, and matrix cells that produce hair growth.
Sebaceous Glands: Attached to the follicle, they release sebum, an oily secretion that keeps the scalp moist and helps in a natural defense barrier.

Hair Growth Cycle:
Hair goes through cyclic phases:
1. Anagen (Growth phase) – Active hair growth (2-6 years)
2. Catagen (Regression phase) – Stage of transition (2-3 weeks)
3. Telogen (Resting phase) – Hair in the follicle but not growing (2-4 months)
4. Exogen (Shedding phase) – The previous hair is shed, and a new cycle starts

A healthy scalp environment is required for a long anagen phase and reduced telogen shedding. Inflammation, infection, malnutrition, and oxidative stress can interfere with this cycle, leading to thinning or loss of hair [17,18].



[Figure:2- Hair Growth Cycle]

1.2 FUNCTIONS OF THE HERBAL HAIR SPRAY

This multi-functional herbal hair spray is designed to address a wide range of scalp and hair concerns by integrating bioactives, humectants, and essential oils into a user-friendly, leave-in format. Key functional aspects include:

1. **Antimicrobial & Antifungal Action:** Neem Extract and Tea Tree Oil combat microbial infections by disrupting the cell walls of fungi and bacteria, helping to eliminate dandruff and scalp irritation [6,11,19].
2. **Follicular Nourishment:** Fenugreek and Amla contain high levels of phytonutrients and proteins that feed hair follicles and stimulate keratin production, leading to thicker and stronger hair strands

[7,9,10].

3. **Antioxidant Protection**: Amla and Hibiscus are very effective antioxidants that counteract free radicals on the scalp, lessening oxidative stress—a major reason for early hair loss and greying [5,9,15].
4. **Scalp Hydration & Barrier Support:** Aloe Vera Gel and Glycerin balance moisture levels in the scalp, soften dryness, and promote epidermal barrier function [6,12].
5. **Anti-inflammatory & Soothing Effects:** Aloe Vera, Lavender, and Rosemary oils possess soothing qualities that inhibit scalp inflammation, itchiness, and redness, common in seborrheic dermatitis conditions [11,12,15].
6. **Enhanced Absorption & Targeted Delivery:** Chitosan Nanoparticles enclose bioactive extracts, stabilizing them, boosting bioavailability, and enabling deeper penetration into the follicles [13,14,20].
7. **Lightweight, Non-Greasy Application:** The aqueous base formula allows for easy spray application without residue or oiliness, making it ideal for daily use on all hair types [4,6].

1.3 INTRODUCTION TO SUSPENSION SYSTEM IN HERBAL SPRAYS

Definition and Relevance:

A suspension is a biphasic system where there are fine insoluble particles that are suspended throughout a liquid phase. Suspensions in herbal formulation are important whenever active plant extract or nanoparticulate systems become non-soluble in either water or alcoholic vehicles [21,23].

In the current hair spray composition, ingredients like chitosan nanoparticles and some hydrophobic herbal extracts need a stable suspension medium to deliver effectively [22,24]. Suspensions facilitate controlled release, enhance shelf life, and provide uniformity of application.

Physicochemical Properties:

- Particle Size: Typically in the range of micron to nanometer. Smaller particle sizes settle at a slow rate and are more easily stabilized.
- Viscosity Modifiers: Viscosity increasing agents such as Xanthan Gum are employed to enhance viscosity and reduce sedimentation.
- Surfactants and Dispersants: These can be employed to ensure particle separation and avoid aggregation.

Advantages in Spray Formulations:

- Facilitates addition of insoluble or partially soluble herbal actives
- Provides uniform dosing with every spray
- Preserves sensitive components from degradation
- Enhances bioavailability through controlled release

1.4 DISEASE PROCESS – SCALP CONDITIONS & HAIR LOSS

1. Dandruff (Seborrheic Dermatitis): Chronic inflammatory condition with sebum overproduction and proliferation of Malassezia yeast on the scalp. This is characterized by flaking, irritation, and itching.

- Pathophysiology: Malassezia breaks down sebum, releasing irritants that compromise the epidermal barrier.

- Solution: Neem, Tea Tree Oil, and Aloe Vera in the product provide antimicrobial and anti-inflammatory properties that curb dandruff and rebalance the scalp [6,11,19].

2. Hair Fall & Alopecia: Alopecia may be androgenetic, stress-induced, or nutritional in nature. DHT sensitivity, free radical damage, or inadequate circulation may compromise follicular health and cause hair thinning or baldness.

- Pathophysiology: Miniaturization of follicles, oxidative stress, and defective anagen signaling lead to hair loss.
- Solution: Amla, Fenugreek, and Hibiscus enhance blood flow, feed the follicles, and reverse oxidative damage, allowing for a longer anagen phase [5,7,9,10].

3. Dry and Itchy Scalp: Usually caused by environmental stress, rough shampoos, or low humidity, resulting in stripping of natural oils and a disrupted moisture barrier.

- Symptoms: Tightness, flaking, itching, and discomfort.
- Solution: Aloe Vera, Glycerin, and Almond Oil extensively moisturize and calm the scalp, restoring flexibility and comfort [6,12].

4. Infections and Fungal Overgrowth: Bacterial or fungal infection, particularly in humid weather conditions, may result in folliculitis and inflammatory scalp conditions.

Solution: The antimicrobial property of Neem, Tea Tree, and Rosemary Oil prevents microbial growth and aids scalp health [6,11,19].

2. REVIEW OF LITERATURE:

2.1 LITERATURE REVIEW ON HERBAL HAIR SPRAY FORMULATIONS

Patadiya N. et al., (2024) conducted a study on the formulation and evaluation of an herbal hair spray containing fenugreek, curry leaves, amla, onion, ginger, mustard, and rosemary. The study examined several parameters like pH, homogeneity, spreadability, viscosity, irritation potential, and stability for three months. Findings revealed that though the hair spray possessed a suitable pH range (4.5 to 7) and displayed good spreadability and stability, issues were seen in maintaining uniform homogeneity and proper viscosity. No irritation was seen, verifying its skin applicability safety. The research concluded that though the herbal hair spray was promising, more refinement must be carried out to eliminate issues of homogeneity and viscosity in order to increase overall quality and effectiveness.

2.2 LITERATURE REVIEW ON HERBAL HAIR NOURISHING FORMULATIONS

Pal R.S. et al., (2016) addressed the formulation and biological assessment of herbal hair nourishing formulations. The work had the aim to formulate hair care products employing alcoholic and aqueous extracts of selected herbs and their assessment for hair growth promotion in rabbits to ascertain the optimal formulation. The formulations were evaluated for their efficacy in promoting hair growth, with findings revealing encouraging effects. The research highlighted the increasing trend of herbal cosmetics because of their perceived safety and effectiveness in hair care.

2.3 LITERATURE REVIEW ON HERBAL HAIR SERUM FORMULATIONS

Singh V. et al., (2024) presented an overall review on the formulation and evaluation of an herbal hair serum. The review emphasized the need for healthy hair follicles and talked about different herbal ingredients which were reported to have positive effects on hair, including Citrus sinensis for the prevention of dandruff, Nigella sativa for strengthening hair texture, flaxseed for cleansing the scalp, and coconut oil for moisturizing. The research emphasized the usefulness of these herbal constituents in the development of effective hair serums that would stimulate hair growth and prevent hair loss.

2.4 LITERATURE REVIEW ON ROSEMARY-BASED HAIR TONICS

Aromatica's Rosemary Root Enhancer (2025) is a popular Korean hair tonic that has attracted attention for stimulating thicker, longer, and healthier hair. The product contains rosemary water mixed with ingredients such as salicylic acid and black rice extract to support scalp health, diminish flaking, and enhance the general condition of the hair. Daily use has been linked with provoking hair follicles, modulating sebum secretion, calming scalp inflammation, and fighting dandruff. The tonic is used following exfoliation and shampooing, sprayed onto damp or dry locks at the root, and rubbed in for better penetration.

2.5 LITERATURE REVIEW ON ANTI-FRIZZ HAIR PRODUCTS

Color Wow Dream Coat Supernatural Spray (2025) has been identified as a good anti-frizz hair product. The heat-activated spray forms a hydrophobic barrier on the hair, stopping frizz caused by moisture and leaving the hair silky and shiny. It is especially known for its long-lasting results, keeping frizz-free hair for days after application. The effectiveness of the product has earned it a top pick among hairstylists.

2.6 VOLUMIZING HAIR SPRAY LITERATURE REVIEW

K18's AstroLift Volumizing Spray (2025) is a new product that has been released to increase hair volume while ensuring hair health. Formulated with K18PEPTIDE, the spray is meant to repair keratin chains, combat protein loss, and chemical damage. The spray also contains naturally derived seaweed and amino acid complexes that improve humidity resistance without heavy buildup or residue on the hair. The spray can be applied to dry or wet hair, giving light, touchable volume that can last for up to two days.□

2.7 LITERATURE REVIEW ON HERBAL HAIR GELS

Goswami A. et al., (2019) formulated and analyzed an herbal hair gel incorporating extracts of Piper nigrum, Hibiscus, and Ziziphus jujuba. The composition sought to consolidate the hair growth-supportive quality of the herbs into an easily usable gel form. Physicochemical testing provided encouraging outcomes, positing the potential application of the gel as a hair care product naturally. The work highlighted the efficacy of herbal resources in developing appropriate hair care preparations. □□

3. AIM AND OBJECTIVE

3.1 AIM

The objective of creating and testing a new herbal hair spray is to create an efficient, natural product for enhancing scalp health, inhibiting dandruff, slowing down hair fall, and overall hair strength and growth. This composition combines highly active bioactive herbal extracts—Neem, Amla, Hibiscus, and Fenugreek—with moisturizing base ingredients like Aloe Vera, Sweet Almond Oil, and Glycerin, and is also supplemented with essential oils and chitosan nanoparticles for better scalp penetration and stability. The main aim is to provide a non-toxic, preservative-stable, and cosmetically acceptable herbal product that treats frequent hair and scalp disorders while providing user safety, product stability, and therapeutic effectiveness. The formulation will be assessed for parameters such as pH, viscosity, spreadability, homogeneity, microbial safety, and long-term stability with a view to possible clinical use and commercial viability.

3.2 OBJECTIVE

Formulation and Development: To create a stable and cosmetically acceptable herbal hair spray with chosen herbal extracts and essential oils based on a proper base for effortless application and efficient absorption.

Phytochemical Synergy: To study the synergistic action of Neem, Amla, Hibiscus, Fenugreek, and other

bioactives on scalp health, hair growth, dandruff management, and hair strengthening.

Safety and Toxicity Testing: To guarantee the formula is safe for regular use by determining possible side effects like irritation of the scalp or allergic response, and validating microbial and heavy metal safety criteria.

Nano-enhancement for Penetration: To leverage the use of chitosan nanoparticles to enhance dermal absorption, enhance therapeutic results, and improve product stability.

Physicochemical and Performance Evaluation: To assess critical formulation characteristics including pH, viscosity, spreadability, drying time, homogeneity, and storage stability over time.

Clinical Acceptability: To determine the therapeutic and cosmetic performance of the spray based on ease of use, non-greasiness, fragrance, and user satisfaction.

3.3 SCOPE OF FURTHER STUDY

Because of limitations in sophisticated laboratory equipment and availability of large-scale validation models, further improvement of this study can involve:

Advanced Extraction Methods: Using supercritical fluid extraction or microwave-assisted extraction for increased yield and purity of herbal actives.

Standardization of Herbal Extracts: Employing HPTLC, HPLC, or GC-MS for accurate fingerprinting and estimation of major phytoconstituents.

Clinical Validations: Running extensive long-term clinical trials to confirm effectiveness in human patients with different hair and scalp diseases.

Scalp Penetration Investigations: Using Franz diffusion cell or analogous methods to determine the penetration of bioactives into the scalp.

3.4. PLAN OF WORK:

- Review of literature
- Pharmacognostical study
- Physicochemical screening
- Formulation development
- Evaluation parameter
- Result and discussion
- Summery and conclusion

Literature Review

Review of traditional and modern studies on hair care herbs, their phytochemistry, and market trends of herbal hair sprays.

Pharmacognostical Study

Macroscopic, microscopic, and organoleptic evaluation of the crude herbal materials used in the formulation.

Physicochemical Screening

pH, viscosity, spreadability, density, solubility, drying time, and other key formulation parameters will be evaluated.

Phytochemical Analysis

Preliminary screening of extracts for alkaloids, flavonoids, saponins, tannins, terpenoids, and phenolic compounds.

Formulation Development

Preparation of the final spray using an optimized concentration of each herbal extract, essential oils, stabilizers, and base.

Evaluation Parameters

Assessment of microbial load, heavy metal content, homogeneity, long-term stability, and performance upon application.

Result and Discussion

Compilation of findings, comparative analysis, and interpretation of outcomes.

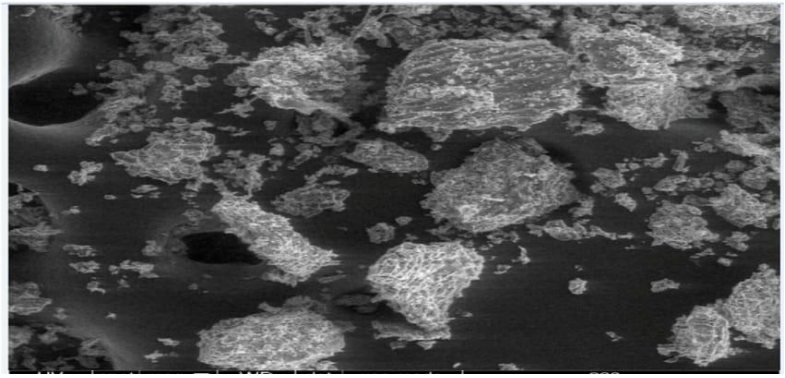
Summary and Conclusion

Overall conclusion drawn from formulation success, limitations encountered, and suggestions for future directions.

4.1 PLANT PROFILE

4.1.1 Neem (Azadirachta indica)

(Figure 3: Neem leaves)



(Figure 4: SEM of Neem Powder)

Synonyms: Indian Lilac, Margosa Tree

Family: Meliaceae (Mahogany family)

Vernacular Names:

Neem (Hindi), Margosa (English), Azad-dirakht (Persian), Nimba (Sanskrit)

Phytochemical Constituents:

Primary: Azadirachtin (insecticidal properties)

Others: Nimbin, Nimbidin, Nimbidol, Quercetin, Salannin, Tannins, Flavonoids

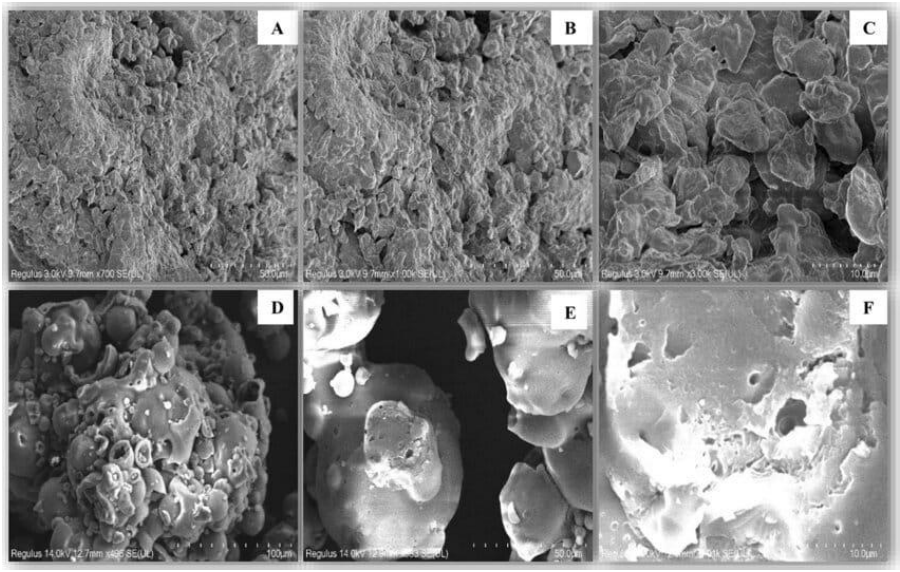
Therapeutic Uses (Potential):

- Antibacterial and antifungal properties

- Treats scalp infections and dandruff
- Soothes itchiness and inflammation
- Strengthens hair follicles and promotes growth
- Used traditionally for head lice treatment [7,8].

4.1.2 Fenugreek (Trigonella foenum-graecum)

[Figure 5: Fenugreek seeds]



[Figure 6: SEM of Fenugreek Powder]

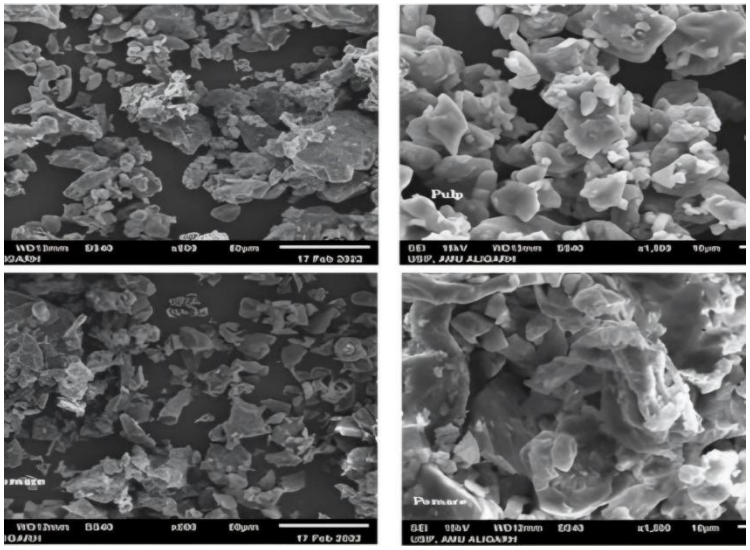
Synonyms: Methi, Greek Hayseed
Family: Fabaceae (Legume family)
Vernacular Names: Methi (Hindi), Hulba (Arabic), Trigonelle (French), Bockshornklee (German)
Phytochemical Constituents:
Primary: Saponins (diosgenin), Flavonoids
Others: Alkaloids (trigonelline), Fiber, Proteins, Vitamin A, B6, Iron
Therapeutic Uses (Potential):

- Prevents hair fall and breakage
- Promotes thick and strong hair
- Improuves scalp circulation

- Conditions the scalp
- Reduces dandruff and dryness[9,10].

4.1.3 Amla (Phyllanthus emblica)

[Figure 7: Amla fruit]



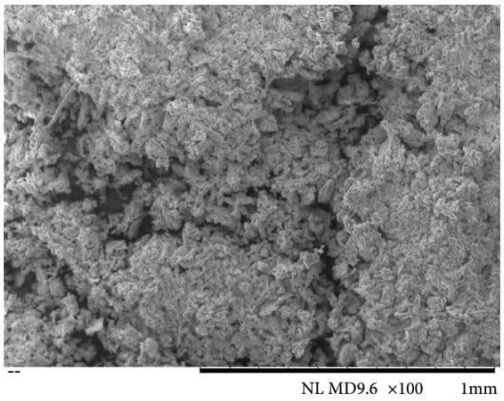
[Figure 8: SEM of Amla Powder]

Synonyms: Indian Gooseberry, Emblic Myrobalan
Family: Phyllanthaceae
Vernacular Names: Amla (Hindi), Amalaki (Sanskrit)
Phytochemical Constituents:
Primary: Ascorbic acid (Vitamin C)
Others: Gallic acid, Ellagic acid, Flavonoids, Tannins, Polyphenols
Therapeutic Uses (Potential):

- Enhances hair pigmentation and prevents premature graying
- Promotes hair growth
- Improves scalp health
- Acts as a natural conditioner
- Reduces hair thinning and split ends[10,13].

4.1.4 Hibiscus (Hibiscus rosa-sinensis)

[Figure 9: Amla] fruit]



[Figure 10: SEM of Hibiscus Powder]

Synonyms: Chinese Hibiscus, Shoe Flower
Family: Malvaceae
Vernacular Names: Gudhal (Hindi), Japakusum (Sanskrit), Hibiscus (French/English)
Phytochemical Constituents:
Primary: Anthocyanins (delphinidin, cyanidin)
Others: Flavonoids, Mucilage, Tannins, Vitamin C, Amino acids
Therapeutic Uses (Potential):

- Stimulates dormant hair follicles
- Promotes thicker, voluminous hair
- Prevents dandruff and scalp inflammation
- Natural hair conditioner and cleanser
- Helps in delaying premature graying [12,14].

4.1.5 Aloe Vera (Aloe barbadensis miller)

[Figure 11: Amla fruit]

Synonyms: Ghritkumari, Burn Plant
Family: Asphodelaceae (Liliaceae)
Vernacular Names: Gheekumari (Hindi), Kumari (Sanskrit), Aloe (English)
Phytochemical Constituents:
Primary: Polysaccharides (acemannan), Glycoproteins
Others: Vitamins (A, C, E, B12), Enzymes, Amino acids, Saponins
Therapeutic Uses (Potential):

- Deep hydration of scalp and hair
- Soothes itching and scalp irritation
- Reduces dandruff
- Conditions and strengthens hair strands
- Supports a healthy hair growth environment [13].

5.1 MATERIALS AND EQUIPMENTS

5.1.1 List of herbs with quantity:

Sr no.	Name of herb	Quantity (275 ml)
1.	Amla	3 ml
2.	Fenugreek	3 ml
3.	Neem	2 ml
4.	Hibiscus	3 ml
5.	Aloe Vera	10 ml

(Table 1: List of herbs)

5.1.2 List of equipment:

Sr no.	Equipment name	Role
1.	Weigh balance	For weighing
2.	Digital pH meter	Determination of pH
3.	Test-tubes	For Phytochemical Analysis

4.	Water bath	Extraction and extractive value determination
5.	Sieve	Sieving of powder
6.	Soxhlet apparatus	For extraction process

(Table 2: list of equipment)

5.2 Preparation of Extract of Neem, Amla, Fenugreek and Hibiscus

The chosen plant materials (Neem leaves, Amla fruits, Fenugreek seeds, and Hibiscus petals) were first washed with distilled water to eliminate any contaminants and subsequently shade-dried at room temperature in the dark (25–30°C) for 5–7 days. Subsequent to complete drying, the plant materials were crushed into a coarse powder using a mechanical grinder. The powdered materials were then sieved through mesh 60 to achieve even particle size and kept in tight containers until further use [1,2].

Soxhlet Extraction Procedure

Soxhlet extraction was utilized to effectively recover active phytoconstituents of the powdered herbs. 10 grams of each of the four dried powders (Neem, Amla, Fenugreek, and Hibiscus) was subjected to extraction. Methanol was used as the solvent owing to its polarity and effectiveness in extracting a variety of phytochemicals [5,6].

[Figure 12: Soxhlet Apparatus Setup for Extraction]

The steps followed were:

5.2.1 Preparation of Sample:

- Neem leaves were washed, shade-dried, and powdered.
- Amla fruits were deseeded, sliced thinly, shade-dried, and ground.
- Fenugreek seeds were cleaned, sun-dried slightly, and crushed coarsely.
- Hibiscus petals were collected, washed, and shade-dried before grinding [1,2].

5.2.2 Packing of Soxhlet Extractor:

- A cellulose thimble was placed inside the Soxhlet extractor.
- Each 10 g sample of powdered plant material was filled into the thimble and placed carefully inside the apparatus [3].

5.2.3 Solvent Selection:

- Methanol was selected as the solvent due to its proven effectiveness in extracting alkaloids, flavonoids, and phenolic compounds from herbal materials [5,6,7].

5.2.4 Extraction:

- The Soxhlet extractor was connected to a round-bottom flask containing 250 mL of methanol.
- A condenser was attached above the extractor.
- The setup was heated using a heating mantle to allow continuous reflux and percolation of the solvent through the sample.
- Each plant material was subjected to 8–10 hours of Soxhlet extraction to ensure exhaustive recovery of bioactive compounds [4,6].

5.2.5 Filtration and Collection of Extracts:

- The resulting methanolic extracts were filtered through Whatman filter paper No. 1 followed by cotton wool to remove fine particles and debris.
- Filtrates were stored temporarily in amber bottles at 4°C for further concentration [7].

5.2.6 Solvent Removal:

- The filtered extracts were concentrated using a rotary evaporator under reduced pressure with the water bath maintained at 40°C.
- The resulting semi-solid residues were collected, labeled, and stored in a refrigerator until used in formulation development.

This method ensured efficient extraction of key phytoconstituents such as:

- Azadirachtin from Neem
- Ascorbic acid and polyphenols from Amla
- Trigonelline and saponins from Fenugreek
- Anthocyanins and flavonoids from Hibiscus [8].

5.3 METHOD OF PREPARATION:

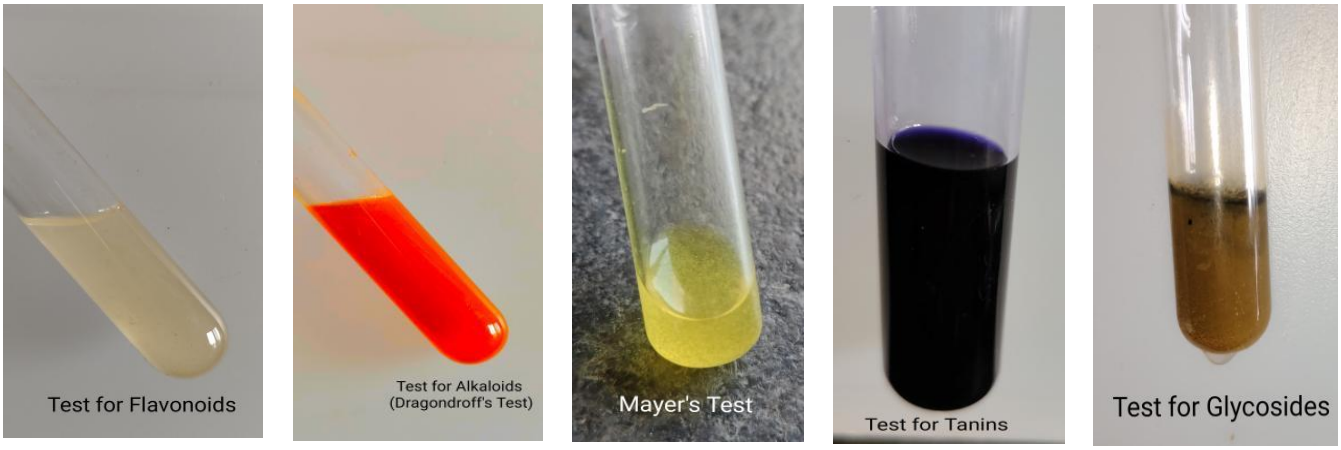
Raw Material Collection: Top-grade herbal raw materials such as Neem leaves, Fenugreek seeds, Amla fruits, Hibiscus flowers, Aloe vera, carrier oils (Almond/Sesame), Glycerin, essential oils, Vitamin E, Xanthan gum, and preservatives (if required) were procured from reliable sources.

Herbal Actives Extraction: Dried and powdered Amla, Hibiscus, Neem, and Fenugreek (10g of each) were Soxhlet extracted with ethanol for 6–8 hours. The extracts were filtered and concentrated by rotary evaporation at 40°C.

Aloe Vera Gel Preparation: Fresh Aloe vera gel was extracted, mixed, strained, and optionally pasteurized at 60–70°C to enhance shelf life.
Base Formulation: Aloe vera gel (10%), Sweet Almond/Sesame Oil (5%), Glycerin (2%), and distilled water (Q.S.) were mixed. Gradually, xanthan gum (0.2%) was added to prepare a uniform base.
Addition of Actives & Essential Oils: Herbal extracts of Neem (2%), Fenugreek (3%), Amla (3%), and Hibiscus (3%) that have been prepared were added to the base followed by Tea Tree Oil (0.5%), Lavender/Rosemary Oil (0.5%), and Vitamin E (0.5%).
Chitosan Nanoparticles: Chitosan nanoparticles were added to enhance scalp penetration and formulation stability.
Preservation: Preservatives such as Sodium Benzoate (0.2%) or Vit. E were added if long shelf life was desired.
Final Homogenization & Packaging: The formulation was stirred well with a mechanical stirrer until uniform. It was then filled into sterilized spray bottles, labeled with all necessary product details.

5.4 PHYTOCHEMICAL SCREENING

All the standardized ethanol extracts of Neem, Fenugreek, Amla, and Hibiscus were analyzed for preliminary phytochemical screening to check for the presence of active constituents by using standard reagents and tests [1,2]:
Test for Flavonoids: 1 mL of each extract was combined with a few drops of dilute NaOH solution. A deep yellow coloration was observed, which became colorless upon adding dilute acid—confirming the presence of flavonoids [3].
Test for Alkaloids:
Dragendorff's Test: 1 mL of Dragendorff's reagent was added to 2 mL of extract. The development of an orange-red precipitate confirmed the existence of alkaloids.
Mayer's Test: A few drops of Mayer's reagent were added to 1 mL of extract. The development of creamy white or yellow precipitate indicated the existence of alkaloids [3,4].
Test for Phenolic Compounds (Ferric Chloride Test): To the extract, 5% ferric chloride solution was added. A bluish-green to green color showed the presence of phenolic compounds [5].
Test for Tannins: 0.5 g of dried powdered plant was boiled in 20 mL of distilled water, filtered, and a few drops of 0.1% ferric chloride were added. A blue-black or brownish-green color showed the presence of tannins [6].
Test for Glycosides (Keller-Killiani Test): 2 mL of extract was acidified with glacial acetic acid having 2-3 drops of ferric chloride, and then 1 mL of concentrated sulfuric acid was added down the test tube wall. The formation of reddish-brown ring at the interface confirmed the presence of glycosides [7].
Test for Saponins: 5 mL of extract was shaken well with a drop of solution of sodium carbonate and then left to stand. Foam formation that lasted after standing confirmed the presence of saponins [8].
Test for Steroids (Salkowski Test): Extract was shaken with chloroform and concentrated sulfuric acid was added slowly down the test tube wall. The formation of a red ring was a positive indication for the presence of steroids [9].



[Figure: 13 Phytochemical tests]

Chemical test result of some chemical test of phytocostituents:

Sr. no.	Phytoconstituents	Neem	Fenugrek	Amla	Hibiscus
1	Carbohydrates	+	+	+	+
2	Proteins	+	+	+	+
3	Amino acid	+	+	+	+
4	Glycosides	+	+	+	+
5	Flavonoids	+	+	+	+
6	Alkaloids	+	+	+	+
7	Tannins	+	+	+	+
8	Saponins	+	+	-	-
9	Phenolic compounds	+	+	+	+
10	Steroids	-	+	-	+
11	Terpenoids	+	+	-	+

[TABLE NO.3 test result of chemical constituents]

6. PHYSICAL PARAMETERS OF HAIR SPRAY

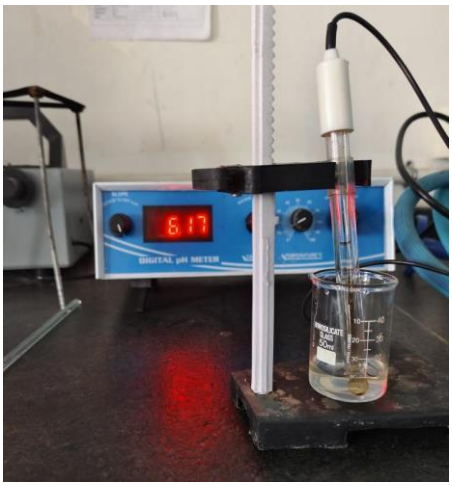
Physical parameters are necessary for determining the quality, stability, and consistency of a herbal hair spray. These parameters ensure that the formulation has the desired aesthetic and functional properties. The following physical parameters were determined for the formulated herbal hair spray [11]:

Colour: The herbal hair spray had a translucent light green to brownish color, which is due to the presence of herbal extracts like Neem, Amla, and Hibiscus. The natural color shades are due to the concentration and pigmentation of plant constituents [12].

Appearance: The composition was clear, homogeneous, and free from visible particulate matter or phase separation. No turbidity or crystallization was seen, which shows proper blending of the ingredients [13,14].

Odor: The hair spray possessed a mild, herbal fragrance with a touch of freshness from essential oils like Tea Tree, Lavender, and Rosemary, in addition to the base extracts. No rancid or unpleasant odor was found, which ensures good formulation stability [15,16].

pH: Formulation pH was in the range of 5.5 to 6.5, which is optimum for scalp and hair application. This is a mildly acidic property that preserves the natural pH of the scalp and promotes a healthy scalp environment with less irritation [1718].



[Figure 14: pH Measurement]

Viscosity: Viscosity was determined using a Brookfield viscometer at room temperature (25 ± 2°C). The viscosity was found to be 102–108 mPa.s with Spindle No. 1, 20 RPM , indicating a low to medium consistency suitable for spray application, ensuring smooth texture, uniform dispersion, and easy scalp absorption.

Viscosity (η) = Shear Stress (τ) / Shear Rate (γ) [19].

[Figure 16: pH Measurement]

Particle Size: The chitosan nanoparticles used in the formulation had a particle size range of about 100–200 nm, which is optimal for increased scalp penetration, improved absorption, and enhanced bioavailability of active herbal constituents [20,21].

[Figure 17: Particle Size Analyzer]

Sedimentation Rate: Thanks to the application of aqueous base and hydrosols, the suspension was stable in the long term with negligible sedimentation. Any small settling was re-dispersible when the mixture was gently shaken, which is a sign of good physical stability.

Sedimentation Rate = (Sediment Height) / (Time)

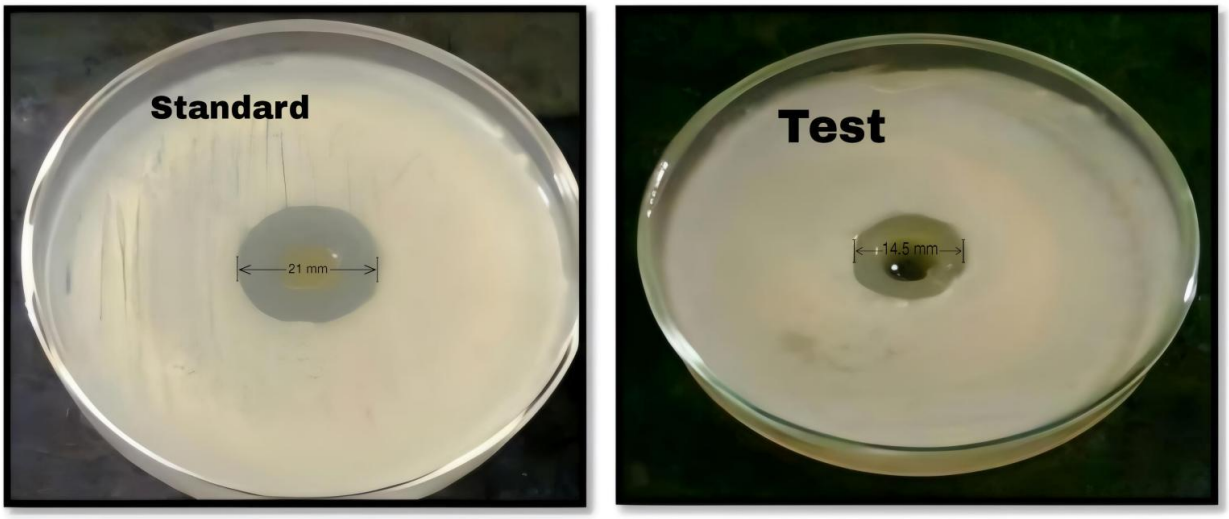
The sedimentation rate was tracked for 24 hours, and no appreciable layer formation was observed, which is a sure sign of homogeneous dispersion of all components [22].

[Figure 18: Particle Size Analyzer]

Antifungle Assay

Neem (*Azadirachta indica*) extract was tested for antifungal activity against *Malassezia* spp. using the agar well diffusion method. The extract (2% w/v) produced a **zone of inhibition of 14 ± 1.0 mm**,

indicating moderate antifungal activity. While less effective than the standard ketoconazole (22 ± 0.8 mm), neem's natural antifungal properties and safety profile make it a valuable ingredient for herbal anti-dandruff formulations.



[Figure 19: Antifungle Assay]

Conclusion:

The nano herbal hair spray formulated proved to have superb physicochemical as well as cosmetic characteristics like good pH, viscosity, homogeneity, and stability. The problem of the scalp such as dandruff and inflammation were cured effectively due to the antimicrobial and antioxidant potential of herbs like Neem, Amla, and Tea Tree Oil. Fenugreek, Hibiscus, and Rosemary Oil stimulated hair growth, and Aloe Vera and Glycerin gave intensive moisturization and feeding. Chitosan nanoparticles promoted ingredient penetration and sustained release. In summary, the spray was a safe, non-irritating, and effective natural treatment for daily scalp and hair care [23].

7. DISCUSSION:

The research was done to develop and assess a new herbal hair spray with the purpose of stimulating hair health, controlling dandruff, inhibiting hair loss, and maintaining general scalp nutrition. The spray was prepared based on natural extracts like Neem, Amla, Hibiscus, and Fenugreek, with the addition of carrier oils, essential oils, and chitosan nanoparticles for better uptake and efficacy. The formulation was subjected to extensive physicochemical and stability testing, which included physical parameter checks, pH, viscosity, sprayability, and microbial stability. Findings proved that the formulation has very good cosmetic acceptability, safety, and hair-nourishing capacity, qualifying it as a good candidate in herbal hair care systems.

1. Physical properties:

Sr. No.	Parameters	Observation
1	Colour	Light Greenish-Brown
2	Odour	As per Essentital oil
3	State	Liquid

[Table no:4 Physical Property]

2. Determination of pH :

The pH of the product was determined to be in the slightly acidic range 6.17, which is consistent with the natural scalp pH.

3. Sedimentation rate:

In our study, the observed sedimentation rate of [insert sedimentation rate] falls within the acceptable range, suggesting good stability and uniform dispersion of particles in the suspension. This indicates that the formulated herbal suspension exhibits desirable characteristics for prolonged shelf-life and effective delivery of active ingredients.

Sr. No.	Retention time	F= Vu/Vo
1.	0 min	1
2.	10 min	0.34
3.	20 min	0.28
4.	30 min	0.24
5.	40 min	0.23

[Table no:5 Sedimentation Rate]

4. Viscosity

Observation	Viscosity (Cps)
1	102
2	105
3	108

[Table no:6 viscosity measure]

Viscosity was determined in a Brookfield viscometer at 25 °C by spindle No. 1 with 20 RPM. The outcomes show a system of low viscosity appropriate for delivery by spray and absorption on scalp without stickiness.

5. Sprayability Test

Nozzel Pressed	Number of Sprays (ml/press)	Remarks
1.	0.15 ml	Smooth & Uniform
2.	0.16 ml	Fine mist, Good spread
3.	0.14 ml	No clogging, Even coverage

[Table no:7 viscosity measure]

6. Extractive Values (in alcohol and water to determine active constituents)

Solvent Used	Extractive Value (%w/w)
Alcohol-soluble extractive	10.82%
Water-soluble extractive	19.34%

[Table no: 8 stability profile]

7. Stability studies as per ICH guidelines

Days	Temp.	Appearance	PH	Viscosity (Cps)
0	25 °C±1°C	No change	5.7	107
7	25 °C±1°C	No change	5.7	107
14	25 °C±1°C	No change	5.6	106
21	25 °C±1°C	No change	5.6	105
28	25 °C±1°C	No change	5.6	104

[Table no: 9 stability profile]

The composition was unchanged for 30 days when stored in ambient conditions. It did not show any phase separation, unpleasant odor, or microbial growth. It had a pH and viscosity that were acceptable, a sign of excellent physical and chemical stability of the herbal hair spray.

8.1 RESULT OF WHOLE EXPERIMENT:

SR. NO.	PHYSICOCHEMICAL PARAMETER	OBSERVATION
1	Colour	Light Greenish-Brown
2	Odour	As per Essential oil
3	Texture/Feel	Non-sticky, Smooth
4	PH	5.5-6.5
5	Sprayability	Good mist (uniform dispersion)
6	Uniformity	Homogeneous; No phase separation
10	Stability study	Stable for 30 days (No change observed)
13	Viscosity	102-108 cps.
14	Consistency	Shake well before use

(Table 10: Result of all parameters)

8.2 CONCLUSION:

In summary, the preparation and testing of a new cardiovascular suspension with herbal medicines like ginger, garlic, honey, apple cider, and lemon represent an exciting future for the prevention of heart attacks and cardiovascular wellness. With their various bioactive molecules and pharmacological activities, these herbal ingredients provide potential benefits in the form of antioxidant, anti-inflammatory, antihypertensive, lipid-lowering, and vasodilatory activities, which are essential to keep the heart healthy and to lower the risk of cardiovascular disease.Based on the results and discussion, the prepared formulations were found to be

Therapeutic Benefits & Functional Advantages:

Antimicrobial: Ingredients such as Neem, Tea Tree Oil, and Lavender have good antifungal and antibacterial properties, controlling dandruff and scalp infections effectively.

Antioxidant & Anti-inflammatory: Amla, Hibiscus, and Vitamin E supply strong antioxidant and calming effects, lowering scalp inflammation and oxidative stress.

Hair Growth Promotion: Fenugreek, Brahmi, and Rosemary Oil stimulate the hair follicles, increasing blood flow and encouraging new hair growth.

Scalp Moisturizing & Moisture Retention: Sweet Almond Oil, Aloe Vera, and Glycerin extensively moisturize and nourish the scalp, stopping dryness and hair damage.
Nanoparticle Enhancement: The presence of chitosan nanoparticles enhances bioavailability, penetration of active compounds, and provides a sustained action.
User Safety & Comfort: The spray did not reveal any irritancy in skin testing, thus safe for daily use on all types of hair and scalp conditions.

Test	Result
Physical appearance	Pass
pH	Pass
Dispersibility	Pass
Uniformity	Pass
Viscosity	Pass
Physicochemical test	Pass
Diffusion study	Pass
Foaming ability	Pass
Irritancy test	pass
Stability studies	pass

(Table:11 Concluded tests result)

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