Formulation and Evaluation of Herbal Hair Conditioner using Fenugreek, Hibiscus and Aloe Vera

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***Abstract*— This study was conducted to prepare and evaluate the effectiveness of a herbal hair conditioner based on a lamellar emulsion system for the management of various hair porosity-related problems. The herbal conditioner was prepared using Aloe Vera, Hibiscus, and Fenugreek, all well-recognized for their moisturizing, strengthening, and hair growth-enhancing potential. Herbal extracts were extracted by the maceration method, followed by incorporation into the multi-emulsion (Water-in-Oil-in-Water) base to enhance stability and active delivery to the hair. The formulated conditioner was tested for colour, texture, pH, stability, foam formation, porosity effect, and microscopic structure. These observations demonstrated that the conditioner was magenta pink in colour, smooth, semi-solid with a pH of 3.65, which is suitable for the hairs. It remained stable at different temperatures and demonstrated mild foaming. In the Float test, an improvement in hair porosity was noticed after treatment. In general, this herbal conditioner imparts excellent Smoothness, shine, and moisture to hair and hence could be a safe and natural alternative to chemical conditioners.**

***Index Terms*—Herbal hair conditioner, Lamellar emulsion, Hair porosity, Aloe vera; Hibiscus extract, Fenugreek extract, Water-in-Oil-in-Water (W/O/W) emulsion, Natural hair care, Hair moisturization, Herbal cosmetics.**

I. INTRODUCTION

Hair is not just about looks; it holds deep personal, cultural, and emotional meaning for many people. Although we do not need to survive, hair plays an important role in our identity, self-confidence, and beauty [(1)]. Today, it is still a big part of fashion and personal style. From a biological view, hair helps with body temperature, protects from sunlight and provides some sensation [(1,4)]. Problems like hair fall, breakage and greying can be caused by internal factors (hormones or poor diet) or external damage (pollution, heat tools or chemicals) [(2,3)].

Washing hair is very important to remove oil, dirt, sweat, dead skin and leftover hair product. If not cleaned, it can lead to itching, dandruff, hair fall or scalp infections. Shampooing can also strip away natural oils and damage the hair's protective layer [(2)]. That is why we use conditioners after shampooing. Conditioners add moisture back, smoothens hair, reduces frizz and tangles and makes hair shiny and easy to manage [(6)]. To really understand how conditioners work, it is very important to know how hair is built and what it is made of [(1,5)].

1.1. Hair structure and composition:

Hair is a thread-like structure made mainly of keratin, a tough and fibrous protein [(7,8)]. It grows from follicles embedded in the dermal layer of the skin [(9)]. Although hair is technically made up of dead cells, it plays important roles in lives, not just in protecting the scalp or regulating body temperature, but also in self-expression and cultural identity [(9,10,11)].

Understanding how hair is built from root to tip is essential in dermatology, trichology, and beauty cosmetology. It helps professionals diagnose hair problems and design better hair care treatments [(10)].

The hair shaft, which is what we style, dye, and care is made up of 3 main layers:

1. Medulla: The medulla is the inner layer of the hair shaft. It is made up of soft, loosely arranged cells that may contain air spaces. In fine or light-coloured hair, the medulla might be very thin or even absent. While its role is not fully understood, it's thought to help with insulation and may influence how light reflects off the hair [(7,9,10)].

2. Cortex: Surrounding the medulla is the cortex, which forms the bulk of the hair strand. This layer is packed with keratin fibres and melanin, the pigment that gives hair its natural colour. The cortex is responsible for the hair's strength, elasticity, and overall structure. This is also the layer affected during chemical treatments like colouring, perming, or straightening [7,9,10].
3. Cuticle: The cuticle is the outermost layer. Think of it as the hair's natural armour. It is made up of overlapping, scale-like cells similar to roof shingles or fish scales that lie flat when healthy. A smooth, intact cuticle keeps moisture in, gives hair its shine, and prevents tangling. But when the cuticle is damaged (from heat, chemicals, or friction), hair becomes rough, dry, and prone to breakage. Damaged cuticle or its lipid coating increases porosity, leading to excessive water absorption and loss, decreased mechanical strength, frizz, roughness, and diminished integrity [7,9,10,11].

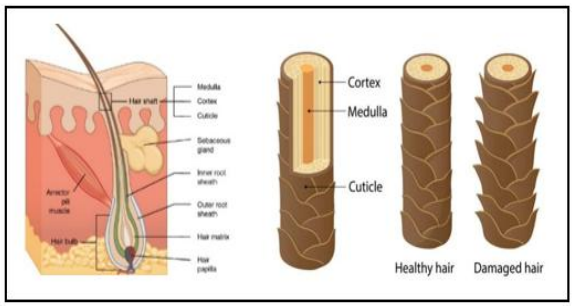

Fig 1 : Structure of hair

1.2. Porosity of hairs:

Hair porosity is the ability of hair fibers to absorb and hold water or other substances. It mainly depends on the condition of the cuticle layer, which acts as a protective shield for the inner cortex [10]. Healthy cuticles lie flat and make hair less porous, while damaged or lifted cuticles allow water to enter and escape quickly [15]. The presence of natural lipids such as 18-methyleicosanoic acid in the cell membrane complex helps keep hair smooth and resistant to excess water entry [14]. When these lipids are lost, hair becomes more porous and become dry and damage [15]. Porosity is usually described as low, medium, or high. Low porosity hair has tightly packed cuticles making, it resistant to water and protecting penetration [15]. Medium porosity hair allows a balanced movement of moisture and is considered healthy. High porosity hair has damaged or missing cuticles, which leads to quick absorption but also rapid moisture loss [15].

This condition is common in chemically treated, heat-styled or environmentally exposed hairs and often results in frizz, roughness and breakage [10]. High porosity also causes over moisturized hair, a weakening of the hair structure due to repeated swelling and shrinking when exposed to water. This makes the fiber fragile and more likely to break. Factors like chemical treatments, UV radiation and Mechanical stress all increase porosity, while genetics also play a role in curly and coily hair, which shows naturally high porosity compared to straight hair [15,16,17]. Because of this, hair conditioners are often designed based on porosity type (light-weight formulas for low porosity and lipid-rich, film-forming emulsions for high porosity) [14,15,17]. Hair Porosity directly guides the design of advanced delivery system such as lamellar gel network emulsion, which mimics biological lipid bilayer and enhances controlled deposition of actives on the hair shaft [12,15].

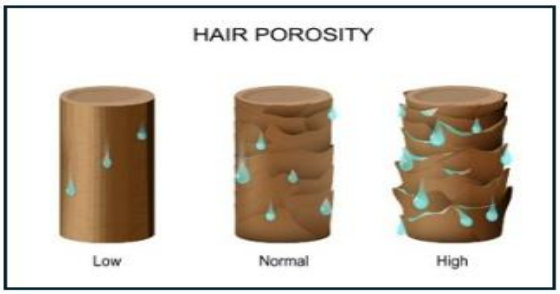

Fig 2: Hair Porosity

1.3. Crystalline lamellar gel network (CLGN):

The lamellar emulsion is an advanced delivery system in cosmetic production. It is a simple oil-in-water or water-in-oil emulsion, CLGN can be structured as water-in-oil-in-water, which means water is trapped inside oil droplets, and these droplets are further dispersed in water [18]. This creates multiple compartments and carries oil and water-soluble ingredients at the same time [19].

In hair conditioner, lamellar emulsions are useful because they look and act like the natural lipid layer of the hair cuticle [20]. This makes them stick better to the hair surface, reduces frizz and keeps moisture locked in [21,23]. For low porosity hair, they can slowly release light moisturizers Aloe Vera to help absorption. For high porosity hair, the layered fatty alcohols fill in the

gap of the damaged cuticle, sealing moisture and giving smoothness.

The w/o/w lamellar emulsion also improves the stability of the product and protects delicate herbal extracts like hibiscus, Fenugreek and Aloe Vera from breaking down. It gives long-lasting moisturization, controlled release of actives, and better shine and manageability for all hair porosity types.

II. PLANT PROFILE

2.1. Aloe Vera:

Aloe Vera is a succulent plant with thick, fleshy leaves that store a clear gel. This gel is rich in water, vitamins, minerals, and polysaccharides, making it widely used in cosmetics. It is known for its moisturizing, soothing, healing, and antioxidant properties. In hair care, Aloe Vera helps hydrate, reduce dandruff and improves hair health, making it a popular ingredient in shampoos and conditioners [25,27,28].

Fig 3(A). Aloe Vera

2.2. Fenugreek:

Fenugreek is an annual herb from the Fabaceae family, widely cultivated for its seeds. The seeds are small, hard, and yellowish-brown, rich in proteins, saponins and mucilage. In hair care, Fenugreek is valued for its conditioning, straightening and hair growth-promoting properties, making it a common ingredient in shampoos, conditioners and hair masks [25,26,27].

Fig 3(B). Fenugreek seeds

2.3. Hibiscus:

Hibiscus is a flowering shrub belonging to the Malvaceae family, commonly cultivated in Tropical and subtropical regions. The plant is known for its brightly coloured flowers which are rich in bioactive compounds such as amino acids, flavonoids, anthocyaninis and mucilage. These compounds contribute to its antioxidant, conditioning and strengthening properties, making Hibiscus a popular ingredient in hair care formulations. It is used to improve hair texture, enhance shine, prevent hair breakage, stimulate hair growth and reduce premature greying. The flower extract is commonly incorporated in shampoos, conditioners, hair oils and masks [24,25,29].

Fig 3(C): Hibiscus

III. METHODS AND MATERIALS

3.1. Extractions:

1. Hibiscus: The hibiscus powder was weighed and macerated in ethanol at a 1:5 ratio for 72 hours [24]. The mixture was then filtered, and the filtrate was concentrated by evaporation on a hot water bath. The dried extract was obtained and used for further formulation.

2. Fenugreek seeds: The fenugreek seeds were cleaned, dried, and ground into fine powder. The powder was macerated into ethanol at a 1:5 ratio for 72 hours with occasional stirring [26]. The mixture was then filtered, and the filtrate was concentrated on a hot water bath to obtain the extract, which was used for further formulation.

3. Aloe Vera gel: Pure Aloe Vera gel was purchased from a commercial source and used directly in the formulation.

Fig 3(D): Extractions of Hibiscus and Fenugreek seeds

3.2. Formulation for preparing conditioner:

Ingredients	Quantity
BTMS-50	1-2.5%
Cetyl alcohol	1-2%
Stearic acid	1-2%
Shea butter	0.5-1.5%
Water	q. s
Hibiscus extract	1-3%
Aloe Vera gel	0.5-2.5%
Fenugreek extract	0.5-1.5%
Glycerine	1-2%
Chitosan	0.05-0.20%
Phenoxyethanol	q. s
Oil	1-2.5%
Citric acid	q. s

Table 1: Formulation Table

3.2.1 Procedure:

- Oil Phase (Phase A): BTMS-50, cetyl alcohol, stearic acid, shea butter, and carrier oils were heated to 75–80°C until completely melted.
- Chitosan was dissolved in citric acid to prepare a uniform solution.
- Water Phase (Phase B): Glycerine and water, chitosan solution was added.
- Emulsification: The heated water phase was slowly added to the oil phase and homogenized for 10–15 minutes.
- Phase C: Hot water, Aloe Vera, Hibiscus, Fenugreek was added gradually under continuous stirring.
- The emulsion was further homogenized for 20–25 minutes to form a uniform microemulsion.
- The microemulsion was checked under a microscope to confirm its structure.
- Phase D: Preservatives, fragrance.
- The formulation was transferred into appropriate containers.

Fig 3(E): Herbal Hair Conditioner

3.3. Evaluation parameters:

1. Physical Evaluation:

The organoleptic test was performed to check the conditioner for colour, smell, odour, texture, consistency and feel.

2. pH Test:

The pH of the conditioner was measured using a digital pH meter. About 1g of conditioner was mixed with 100ml of Distilled Water and stirred well. The pH meter was calibrated before use, and the readings of the conditioner were taken.

3. Stability Test:

The stability of the conditioner was evaluated by storing 1g of samples under different conditions: refrigerator (4-8°C), in an oven (50°C), exposed to light, and at room temperature (25-27°C). Observations were recorded periodically to assess any changes in texture, colour, odour, phase separation, and appearance.

4.Foam Test:

For the foam test, a measured amount of the conditioner was placed in a graduated cylinder. The cylinder was shaken vigorously 15-20 times, and the foam height was recorded immediately.

5.Float Test:

For the Float Test, hair strands were first cleaned and dried before being placed on the surface of Distilled

Water. Hair strands that floated indicated low porosity, those that remained suspended in the middle indicated medium porosity (healthy hairs), and strands that sank indicated high porosity. This was performed both before and after applying the conditioner to assess changes in the hair porosity and evaluate the conditioner's effect.

6.Microscopic Evaluation:

For Microscopic Evaluation,1g of conditioner was diluted in Distilled Water and sonicated for 10 min to reduce particle size. A small amount of the prepared sample was placed on a clean glass slide, covered with a coverslip, and examined under a microscope at 40X and 100X magnifications to observe microstructure, drop size and distribution.

3.4. Results:

1	pH	3.65
2	Colour	Magenta pink
3	Texture	Smooth
4	State	Semisolid
5	Odour	Pleasant herbal fragrance
6	Stability	Stable at all temperatures
7	Foam	Mild form present

Table 2: Result Table

8.Microscopic evaluation:

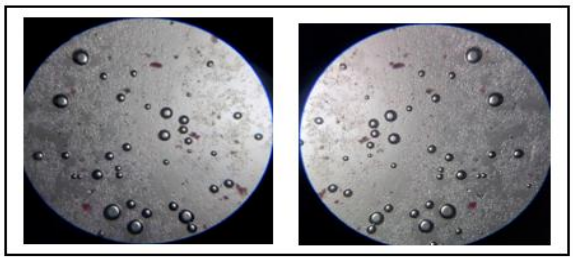

Fig 4(A): Microscopic evaluation

Microscopic evaluation showed a droplet distribution, confirming the formation of a stable multi-emulsion.

9.Float Test:

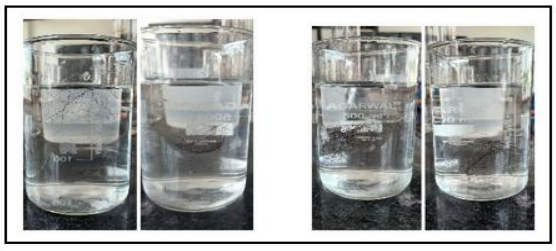

Fig 4(B): Float Test

The water float test showed significant improvement in hair porosity after conditioner application. Many strands that previously sank in the water indicated high porosity with damaged cuticles. Following the treatment, most of these strands stayed in suspension or floated, which indicated reduced porosity with an improvement in cuticle integrity. This demonstrates that the conditioner succeeded in sealing the gaps in the cuticle and the hair is now more hydrated. The collective action of Aloe Vera as a humectant and moisturizer, Hibiscus as a natural conditioner containing a high mucilaginous and amino acid content, and Fenugreek, which acts by providing proteins and saponins for strengthening the hair, succeeded in improving smoothness, shine, and manageability.

IV. RESULT AND DISCUSSION

The developed herbal hair conditioner with Fenugreek, Hibiscus, and Aloe Vera exhibited excellent physicochemical and functional properties regarding effective hair conditioning. The colour of the conditioner was magenta pink on account of hibiscus pigments, while the texture was smooth and semisolid, with a pleasant herbal aroma, which reflects good aesthetic quality. The pH was 3.65, falling within the ideal pH range for hair products, from 3.5 to 5.5, which helps maintain scalp health and smoothens the cuticle layer. Stability studies showed that the formulation was uniform without any phase separation, odour change, or degradation under different temperature conditions, which supported its thermal and physical stability. The mild foaming property also indicated a non-irritating, gentle formulation suitable for regular use.

Microscopic examination revealed a uniform droplet distribution, confirming the formation of a stable multi-emulsion (W/O/W) system that would offer an improvement in the controlled release of active ingredients, enhancing adherence to the hair surface. The float test showed that hair porosity was drastically improved after using conditioner; hair strands that previously sank, meaning they were highly porous, started floating or remaining suspended, indicating medium porosity and restored cuticle integrity. This may be ascribed to the combined actions of Aloe Vera's moisturizing polysaccharides, Hibiscus' mucilage and

amino acids, and Fenugreek's protein-rich saponins, which provided nourishment and strengthening of the hair shaft in general.

Overall, the obtained results indicate the efficiency of this lamellar emulsion-based herbal conditioner to improve hair texture and shine, increasing its manageability while repairing the damage and reducing porosity. The stability, safe pH, and natural composition make this an ideal and eco-friendly alternative for synthetic conditioners, with continued hydration and strengthening action for all hair types.

V. CONCLUSION

The herbal hair conditioner prepared using Fenugreek, Hibiscus, and Aloe Vera proved to be effective, safe, and suitable for regular use. The formulation showed good texture, colour, pleasant fragrance, stable pH, and remained stable at all temperatures. The lamellar emulsion system helped the active ingredients stick better to the hair and improved moisture retention. Test such as float test and microscopic analysis confirmed that the conditioner reduced hair porosity, strengthened the cuticle, and made hair smoother, shinier, and easier to manage. Overall, this herbal hair conditioner can be used as a natural alternative to chemical conditioners for improving hair health.

VI. FUTURE PROSPECTS

This study can be further expanded by testing the conditioner on a larger number of volunteers with different hair types and porosity levels. Advanced studies such as FTIR, SEM, viscosity analysis and swelling- shrinking behaviour can be performed to understand the mechanism in more detail. The formula can also be improved by adding other natural actives, using cold process emulsifiers, or converting the product into a leave-in conditioners or hair mask. With more research, this herbal conditioner has the potential for commercial development as an eco-friendly, effective hair care product.

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