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Research Paper

Formulation and Evaluation of Flaxseed Hair Gel

Senthilraja M.[1], Hemapriya M.*[2], Kodhai V.[3], Pavithra N.[4], Mounika R.[5], Perarasu P.[6]

[1]*Principal and Professor, PSV College of Pharmaceutical Science and Research, Krishnagiri.*
[2,3,4,5,6]*PSV College of Pharmaceutical Science and Research, Krishnagiri*

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ABSTRACT

The present study focuses on the formulation and evaluation of an herbal hair gel incorporating flaxseed gel extract, curry leaves extract, and hibiscus extract to enhance hair health. These natural ingredients are known for their nutrient-rich composition, including essential fatty acids, flavonoids, and polyphenols, which contribute to hair growth, scalp nourishment, and antioxidant protection. The gel formulation was prepared using a flaxseed-based gel matrix, ensuring a natural and stable consistency. Curry leaves extract (Murraya koenigii) was included for its rich antioxidant and antimicrobial properties, while hibiscus extract (Hibiscus rosa-sinensis) was incorporated for its conditioning and hair-strengthening benefits. The prepared formulation was evaluated for its physicochemical properties, including pH, viscosity, spreadability, and stability. Additionally, phytochemical analysis was conducted to confirm the presence of active compounds such as flavonoids, tannins, and alkaloids. The antioxidant potential of the herbal gel was assessed using the DPPH assay, demonstrating significant free radical scavenging activity, indicative of its ability to protect hair from oxidative stress and environmental damage. Overall, the formulated herbal hair gel exhibited desirable stability, antioxidant activity, and beneficial hair care properties, making it a promising natural alternative to synthetic hair gels. This study highlights the potential of herbal extracts in cosmetic formulations, supporting their application in sustainable and effective hair care solutions.

INTRODUCTION

Gel

A gel is a semi-solid system in which a liquid phase is trapped within a three-dimensional cross-linked network of polymers or colloidal particles. Gels exhibit both solid-like and liquid-like properties, making them useful in various applications, including pharmaceuticals, cosmetics, food, and materials science [(1)].

Types of Gels

***Corresponding Author:** Hemapriya M.
Address: *PSV College of Pharmaceutical Science and Research, Krishnagiri*
Email ✉: priyahema660@gmail.com

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Gels can be classified based on different criteria such as their nature, structure, and source.

1. Based on the Nature of the Dispersing Medium

- **Hydrogels:** These are gels in which the dispersing medium is water. They have a high water content and are used in biomedical applications like drug delivery and wound healing [2].
- **Organogels:** These are gels in which the dispersing medium is an organic solvent. They are used in pharmaceuticals and cosmetics, such as ointments and creams [3].
- **Xerogels:** These are dried gels that can absorb water and swell upon hydration, used in controlled drug release and tissue engineering [4].

2. Based on the Source of the Gel

- **Natural Gels:** Derived from natural sources like gelatin, agar, and alginate. These gels are biodegradable and widely used in the food and pharmaceutical industries [5].
- **Synthetic Gels:** Made from synthetic polymers such as polyvinyl alcohol and polyethylene glycol, which provide more control over properties like mechanical strength and stability [6].

3. Based on the Type of Cross-Linking

- **Physical Gels:** Formed by non-covalent interactions such as hydrogen bonding, ionic interactions, or van der Waals forces. These gels are reversible and sensitive to environmental changes [7].
- **Chemical Gels:** Formed by covalent cross-linking of polymers, leading to irreversible gel formation with high mechanical stability [8].

Applications of Gels

Gels are widely used in different industries:

- **Pharmaceuticals:** Drug delivery systems (e.g., transdermal gels, hydrogels for wound healing).
- **Cosmetics:** Skin-care products such as moisturizers and face masks.
- **Food Industry:** Thickening agents in products like jellies and yogurts.
- **Biomedical Engineering:** Tissue engineering scaffolds and biosensors.

Hair

Hair is a keratinized structure that emerges from hair follicles located in the dermis. It serves various functions, including thermoregulation, protection, sensory perception, and social or aesthetic significance. Structurally, hair consists of three main layers: the ***medulla, cortex,*** and ***cuticle***. The hair follicle, a complex mini-organ, undergoes cyclic phases of growth, including anagen (growth phase), catagen (regression phase), and telogen (resting phase), which are regulated by genetic, hormonal, and environmental factors [9,10].

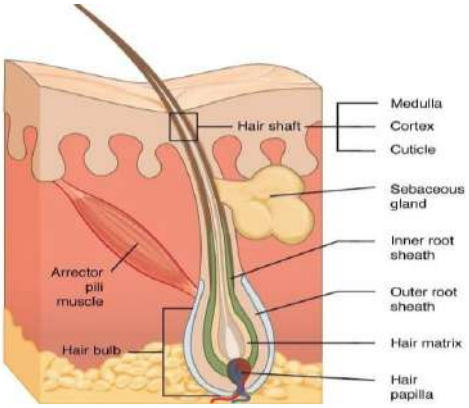


Fig no: 1 Structure of Hair

Anatomy of Hair [11]

Hair consists of two main parts:

1. Hair Shaft: The hair shaft is the visible, non-living portion of the hair. It is composed of three distinct layers:

- ✓ **Medulla:** The innermost layer, found mainly in thick terminal hairs, composed of loosely connected keratinized cells.
- ✓ **Cortex:** The thickest layer, made of densely packed keratinized cells, responsible for the hair's strength, elasticity, and color (due to melanin).
- ✓ **Cuticle:** The outermost layer, composed of overlapping scale-like cells that protect the hair shaft from damage.

2. Hair Follicle: The hair follicle is a dynamic, living structure embedded within the dermis. It consists of the following components:

- ✓ **Hair Bulb:** The base of the follicle, housing the dermal papilla, which supplies nutrients and growth signals via capillaries.
- ✓ **Matrix Cells:** Located within the bulb, these rapidly dividing cells generate new hair. Melanocytes in this area provide pigmentation.
- ✓ **Outer and Inner Root Sheaths:** Protective layers surrounding the hair shaft, guiding its growth.
- ✓ **Sebaceous Gland:** Secretes sebum (oil) into the follicle, providing moisture and preventing dryness.
- ✓ **Arrector Pili Muscle:** A small, smooth muscle attached to the follicle that contracts in response to cold or fear, causing "goosebumps."

Physiology Of Hair Growth [12]

Hair growth follows a cyclic process consisting of three main phases:

1. Anagen (Growth Phase)

The longest phase (lasting 2–7 years), where active cell proliferation occurs in the matrix.

On average, hair grows 1 cm/ month.

The duration of anagen determines hair length, varying among individuals.

2. Catagen (Transition Phase)

A short phase (2–3 weeks) where hair growth slows, and the follicle shrinks.

The hair detaches from the dermal papilla, ceasing nutrient supply.

3. Telogen (Resting Phase)

Lasts about 3 months, during which the hair remains in place but is no longer growing.

Shedding occurs naturally, with 50–100 hairs lost per day. A new anagen phase begins, and the cycle repeats.

Functions of Hair [9,10]

1. **Protection:** Eyelashes and nasal hairs prevent dust and pathogens from sensitive areas. entering
2. **Thermoregulation:** Scalp hair reduces heat loss, and body hair aids in temperature regulation.
3. **Sensory function:** Hair follicles have mechanoreceptors that detect touch stimuli.
4. **Social and psychological impact:** Hair plays a significant role in self-identity, cultural expression, and psychological well-being.

1. Plant Profile:

1.1. Flaxseed:

Flaxseed, also known as linseed, is a nutrient-rich food and fiber crop that has been cultivated for thousands of years. It is a versatile crop with various uses, including food, feed, fiber, and medicine [13].

Fig no: 2 Flaxseed

Family Name: Flaxseed belongs to the Linaceae family, which is a family of flowering plants commonly known as the flax family.

Botanical Name: The botanical name of flaxseed is Linum usitatissimum.

Other Names: Flaxseed is also known by other names, including – Linseed, Common flax, Linen flax, Flax.

Origin: Flaxseed is native to the region extending from the eastern Mediterranean to India.

Cultivation: Flaxseed is cultivated in many parts of the world, with the top producers being Canada, China, and India.

Phytoconstituents: Lignans, omega-3 fatty acid, dietary fiber, phenolic acid, flavonoids, alkaloids and saponins, mucilage [14,15].

Uses of Flaxseed in Hair Gel: Natural Styling Gel, Moisturizer for Dry Hair, Curl Enhancer, Scalp Health & Growth Booster, Reduces Frizz & Adds Shine, Heat Protection.

1.2. Curry Leaves:

The curry leaf, also known as kariveppilai in Tamil, is a plant that is found throughout India and has been used for millennia in Sri Lanka and South India to season vegetables, chutneys, curries, etc drinks. It was brought to Malaysia, Burma, and Singapore by South Indian traders. It was referred known as curry leaf by the British when they were in India, after the seasoned sauce (called kari in Tamil) to which it was added. India is well-known for its vast medicinal plant biodiversity. [16]

Fig no: 3 Curry leaves

Botanical Name: *Murraya koenigii*

Family: Rutaceae (Citrus family)

Origin: Indian curry leaves are indigenous to the Indian subcontinent and can be found almost anywhere. It can also be found in Sri Lanka and many other parts of south-east Asia, such as Thailand, Indonesia, and Burma [17].

Chemical constituents: Compounds including alkaloids, flavonoids and sterols have been extracted using solvents like ethyl acetate, ethanol, petroleum ether, water and chloroform. Koenigine, koenine, koenidine and (-) mahanine were separated from leaves using an acetone extract. Form the hexane mahanimbine, isomahanimbine, koenimbidine and murrayacine where isolated. Isomahanimbicine was isolated in the petroleum ether. [18]

Uses of Curry Leaves: Delays Premature Graying, Prevents Hair Loss, Improves Scalp Health, Restores Hair Shine, Restores Hair Shine.

1.3. Hibiscus:

Hibiscus is a tropical plant known for its large, showy flowers and numerous health benefits. Native to East Asia, Hibiscus has been used in traditional medicine for centuries. Its flowers, leaves, and stems are rich in vitamins, minerals, and antioxidants, making it a popular ingredient in teas, jams, and skincare products. Hibiscus is also revered for its cultural and symbolic significance, being the national flower of Haiti and Malaysia [19].

Fig no: 4 Hibiscus

Botanical Name: Hibiscus rosa-sinensis

Family: Malvaceae

Common Names: Hibiscus**,** Rose Mallow**,** Shoe Flower**,** Tropical Hibiscus

Origin: Native to East Asia, specifically China and India

Description: Hibiscus is an evergreen shrub or small tree that grows up to 15 feet tall. It has large, showy flowers with five petals, ranging in color

from pink, orange, yellow, red, and purple. The leaves are dark green, ovate, and have a toothed margin.

Cultivation: Hibiscus prefers well-drained soil and full sun to partial shade. It thrives in warm temperatures between 64°F to 90°F (18°C to 32°C). For optimum growth, regular fertilization and watering are required.

Phytoconstituents: Flavanoids, saponins, glycosides, phenolic compounds.

Uses: The plant has been used in traditional medicine for its anti-inflammatory, antioxidant, and antiviral properties. Hibiscus extract is used in skincare products for its antioxidant and anti-aging properties.

MATERIALS AND METHODS:

2.1. Materials Needed For Flaxseed Extract:

Flaxseed, cheese cloth, hot plate, stirrer, beaker, water.

Extraction Procedure [20]:

1. Prepare the Cloth: Place a cheesecloth or muslin cloth over a bowl.
2. Pour the Gel: Pour the hot gel mixture onto the cloth.
3. Squeeze: Gather the edges of the cloth to form a pouch and squeeze out the gel into the bowl. Be careful when squeezing hot gel; let it cool slightly if needed.

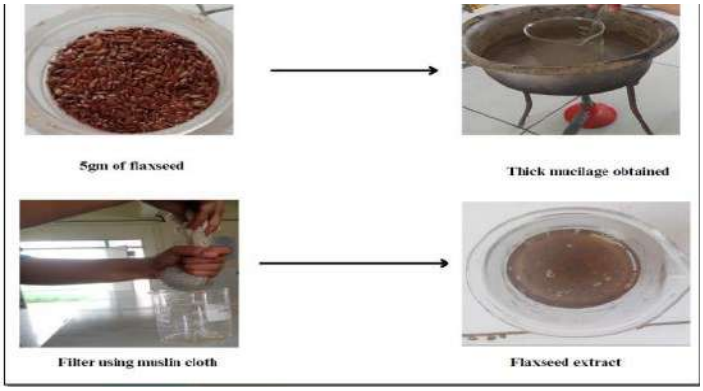


Fig no: 5 Extraction of Flaxseed

2.2. Materials Needed for Curry Leaves Extract:

Fresh or dried curry leaves, Water, Glass container with a lid, Filter paper, Cheesecloth or a clean cotton cloth

Extraction Procedure [21,22]:

1. Collection and Preparation of Curry Leaves: Collect fresh curry leaves and wash them with distilled water to remove any dirt or impurities. Alternatively, use dried curry leaves.

2. Weighing and Chopping: Weigh 10-20 grams of fresh or dried curry leaves and chop them into small pieces to increase the surface area.

3. Water Extraction: Transfer the chopped curry leaves to a glass container with a lid. Add 100-200 mL of water to the container, making sure that the curry leaves are completely submerged in the solvent.

4. Steeping and Heating: Allow the mixture to steep for 30 minutes to 1 hour at room temperature. Alternatively, heat the mixture at 80-90°C for 30 minutes to enhance the extraction process.

5. Filtration: Filter the mixture through filter paper or cheesecloth into another glass container. Discard the solids.

6. Concentration (Optional): If desired, use a rotary evaporator or heat the extract gently to remove excess water and concentrate the extract.

7. Storage:

- Store the extracted solution in an airtight container.
- Keep it in a cool, dark place to preserve its active compounds.

Fig no: 6 Extraction of Curry leaves

2.3. Materials Needed for Hibiscus Extract:

Hibiscus flowers (fresh or dried)**,** Methanol (99.9% purity)**,** Glass container with a lid**,** Filter paper.

Extraction Procedure [21,22]:

1. Collection and Preparation of Hibiscus Flowers: Collect fresh hibiscus flowers and dry them in a cool, dry place. Alternatively, use dried hibiscus flowers.

2. Weighing and Grinding: Weigh 10-20 grams of dried hibiscus flowers and grind them into a fine powder using a mortar and pestle or a grinder.

3. Methanol Extraction: Transfer the ground hibiscus powder to a glass container with a lid. Add 100-200 mL of methanol to the container, making sure that the hibiscus powder is completely submerged in the solvent.

4. Steeping and Shaking: Allow the mixture to steep for 2-3 hours at room temperature. Shake the container every 30 minutes to ensure maximum extraction.

5. Filtration: Filter the mixture through filter paper into another glass container. Discard the solids.

6. Concentration (Optional): If desired, use a rotary evaporator to concentrate the extract by removing excess methanol.

Fig no: 7 Extraction of Hibiscus

FORMULATION

Table :1 Ingredients used in formulation of gel

Ingredients	Functions	Quantity
Flaxseed gel extract	Provides hydration	10%
Hibiscus extract	Strengthens hair, promotes growth	5%
Curry leaves extract	Nourishes scalp, prevents hair fall	5%
Carbopol 940	Gel-forming agent	0.5%

PEG	Moisturizer	2%
PVP	Film-forming agent	3%
Triethanolamine	pH adjuster, neutralizer	0.5%
Methyl paraben	Preservative	0.2%
Glycerine	Humectant, moisture retention	3%
Almond oil	Nourishing agent	2%
Vitamin E capsule	Antioxidant, hair conditioning	1%

PROCEDURE [23,24]:

1. Hydration of Carbopol 940:

Disperse Carbopol 940 in a portion of distilled water (about 50% of the total water content). Allow it to swell for 30–60 minutes for proper hydration.

2. Preparation of Aqueous Phase:

In a separate beaker, dissolve PVP and PEG in a small portion of distilled water. Add Methyl Paraben and Glycerine, mixing until completely dissolved.

3. Incorporation of Extracts:

Mix Flaxseed Gel Extract, Hibiscus Extract, and Curry Leaves Extract into the aqueous phase under gentle stirring.

4. Blending of Oil Phase:

Add Almond Oil slowly into the aqueous phase while continuously stirring.

5. Gel Formation:

Gradually add the hydrated Carbopol 940 to the aqueous mixture while stirring. Slowly add Triethanolamine (TEA) dropwise to neutralize and form the gel structure. Adjust the pH to 5.5–6.5. Pierce the Vitamin E capsule and add the contents to the gel. Mix thoroughly to ensure even distribution.

6. Final Adjustments:

Stir the mixture continuously until a smooth gel consistency is achieved.

7. Storage:

Transfer the gel into a sterile container and store it in a cool, dry place.

Shelf Life: ~3–6 months with proper storage.

Fig no: 8 Flaxseed gel

3. Phytochemical Test:

3.1. Phytochemical analysis of Flaxseed extracts

a) Detection of Lignans [25]

- **Nitric Acid Test:** This test involves the reaction of the lignan with nitric acid.
- **Potassium Hydroxide Test:** This test involves the reaction of the lignan with potassium hydroxide.

b) Detection of Alkaloids

- **Dragendroff's test:** Dissolve the herbal medication's extract in chloroform. After the chloroform has evaporated, add a few drops of

Dragendroff's reagent (potassium bismuth iodide) to the residue to acidify it.

c) Detection of Omega 3 fatty acid [26]

- **Iodine Value Test:** This test measures the amount of iodine absorbed by the fatty acid, which is indicative of its degree of unsaturation.
- **Bromine Test:** This test involves the reaction of the fatty acid with bromine, resulting in a reddish-brown-colored complex.

d) Detection of flavonoids [27]

- **Lead acetate test:** This test involves the reaction of the sample with lead acetate.
- **Ferric chloride test:** This test involves the reaction of the sample with ferric chloride.

3.2. Phytochemical analysis of Hibiscus extract:

a) Detection of Anthocyanin [28,29]

- **Bisulfite Test:** Anthocyanins react with bisulfite to form a colorless compound
- **Lead Acetate Test:** Anthocyanins react with lead acetate to form a blue-black precipitate.

b) Detection of alkaloids:

- **Dragendroff's test:** Take chloroform to dissolve the herbal extract. Chloroform should be evaporated, and the residual should be acidified by adding a few drops of Dragendroff's reagent (potassium bismuth).
- **Mayer's test:** To 2-3ml of filtrate add few drops of Mayer's reagent.

c) Detection of phenols:

Ferric chloride test: A small amount of the extract was exposed to the 5%.

3.3. Phytochemical Analysis Of Curry Leaves Extract:

Detection of Saponin [30]

- **Molisch's Test:** Saponins react with Molisch's reagent (α-naphthol) to form a purple-colored complex.

4. EVALUATION TEST:

4.1. Physical Appearance:

Visual inspection was done to assess the herbal hair gel formulation's color and texture upon application.

4.2. Spreadability:

2 gm of hair gel was placed between 2 glass slides. The slides were loaded with 500g of weight. For 5 minutes, the weight was in place for the defined duration of time. The hair gel spreads in a circular way its diameter was measured from different points [31]. Spreadability was determined by using a formula.

S=M.L/T

Where, **S**= Spreadability, **M**=weight on the slide, **L**=Diameter of the formed circle (cm), **T**=time (sec)

4.3. pH Determination:

The pH of various hair gel formulations was determined following their manufacturing process. After dissolving 1g of hair gel in 100ml of distilled water, the mixture was left for two hours. pH was measured after two hours. For every herbal hair gel composition, the pH was measured twice, and the average was calculated [31].

4.4. Homogenecity:

Following gel preparation, the gel's appearance was examined for lumps and aggregates [32].

4.5. Washability:

Following the application of the prepared hair gel formulation to the skin, the degree and ease of water washing are assessed as usual [31].

4.6. Skin Irritation:

After applying the herbal hair gel formulation to the skin, check for rashes, redness, or irritation [31].

4.7. Stability study:

The ability of a formulation to endure various environmental conditions, such as heat, cold, wetness, and humidity, while maintaining its medicinal, chemical, physical, and toxicological characteristics is known as stability. Stability testing allows for the establishment of suggested storage conditions, retest intervals, and shelf lives by demonstrating how the quality of a drug

substance or drug product changes over time under the impact of various environmental elements including light and humidity. In the current study, the formulation was kept for 30 days at room temperature (25–30ºc) and its physical properties and evaluation parameters were monitored for any changes [31].

Dpph Test for Anti-Oxidant Activity:

- Oxidant stress results when the biological system's antioxidant capacity is exceeded by the production of reactive oxygen species (ROS).
- Free radical oxidative stress has been implicated in the pathogenesis of a variety of human diseases such as atherosclerosis, diabetes mellitus, hypertension, inflammation, cancer and AIDS [33].
- A class of compounds known as antioxidants, which are frequently oxidized themselves, greatly block or delay oxidative processes when present at low concentrations in proportion to oxidizable substrates.
- Antioxidants may exert their effect on biological systems by different mechanism including electron donation (as reducing agents), metal ion chelation (thereby eliminating potential free radicals), sparing of antioxidants [34].
- Antioxidants lower the capacity to absorb free radicals and stabilize them, which reduces their burden.
- The DPPH scavenging assay is a simple chemical experiment used to evaluate the feasibility and cost-effectiveness of any substance in terms of its ability to scavenge free radicals. [35,36].

PROCEDURE:

- DPPH test is modified based on the technique of.
- In brief, 80µl of DPPH solution; various concentration of test solution and quantity sufficient to 240µl with HPLC grade methanol.
- The different concentrations tested for reference standard are 30-1.25 µl/ml.
- The different concentrations tested for the test samples are, 320-10 µl/ml.
- The reaction mixture is mixed with and incubated at 25^0C for 15 minutes.
- The absorbance is measured at 517nm using semiauto analyzer. A control reaction is carried out without the test sample.

Formula:

$$\text{Scavenging Activity (\%)} = \frac{\text{Acontrol} - \text{Asample}}{Acontrol} \times 100$$

The Value of The Standard's Assay Table (E.G., Ascorbic Acid):

Table :2 Assay values for Standard

Concentration (µg/mL)	Absorbance at 517nm	Scavenging activity (%)
5	0.420	21.0%
10	0.350	35.0%
25	0.210	58.0%
50	0.120	76.0%
100	0.050	90.0%

Acontrol = 0.532 (constant for all calculation)

The Assay Table Values for The Test Sample (Flaxseed Gel):

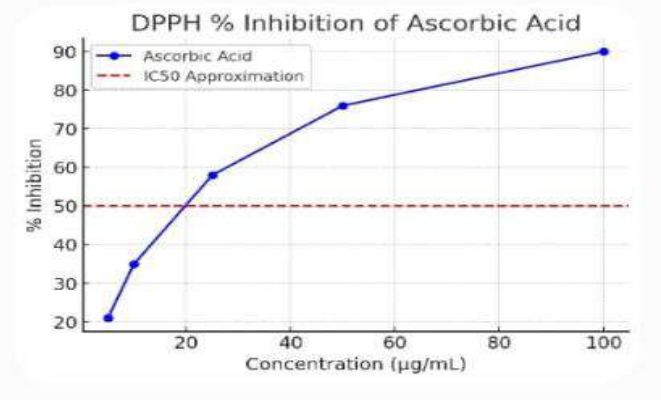
Table :3 assay values for Test sample

Concentration (µg/mL)	Absorbance at 517nm	Scavenging activity (%)
5	0.490	8.0%
10	0.450	15.4%

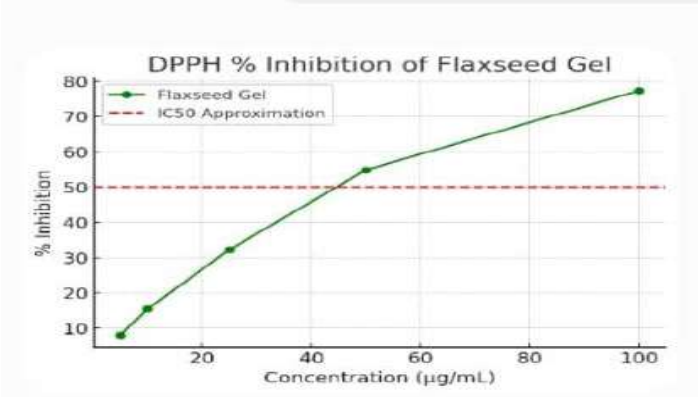
25	0.360	32.3%
50	0.240	54.9%
100	0.120	77.4%

Acontrol = 0.532 (constant for all calculation)

Standard (ascorbic acid):



Test (flaxseed gel):



Conclusion of DPPH test:

The Gel demonstrated antioxidant activity in the DPPH assay, with an IC50 value of 40.36µM. This indicates that the gel has a moderate ability to neutralize free radicals. The percentage inhibition of the gel increased with concentration, reaching 77.4% at 100µM. These results suggest that while the gel does possess antioxidant properties, it is less effective than ascorbic acid, which showed high antioxidant activity with an IC50 value of 10.68µM.

RESULT AND DISCUSSION:

Table :4 Phytochemical screening of *Flaxseed Extract*

S.NO	Plant constituents	Test performed	Result
1.	Test for Lignans	Nitric acid test, Potassium hydroxide test	+
2.	Test for alkaloids	Dragendroff' test	+
3.	Test for Omega 3 fatty acid	Iodine value test, Bromine test	+
4.	Test for flavonoids	Lead acetate test, Ferric chloride test	+

Table:5 Phytochemical screening of *Hibiscus extract*

S.NO	Plant constituents	Test performed	Result

1.	Test for anthocyanins	Bisulfite test, Lead acetate test	+
2.	Test for alkaloids	Dragendroff's test, Mayer's test	+
3.	Test for phenols	Ferric chloride test	+

Table:6 Phytochemical screening of Curry leaves extract

S.NO	Plant constituents	Test performed	Result
1.	Test for saponins	Molisch's test	+

1. **Physical appearance:**
   The herbal gel formulations had light pink colors and a translucent appearance. They were very smooth to apply.
2. **Spreadability:**
   Spreadability contributes to consistent application and is crucial to customer approval.
3. **pH determination:**
   All of the herbal gel formulations had pH values between 6.7 and 7.3, which was suitable for the hair and showed that the formulations were compatible with it.
4. **Homogeneity:**
   The homogeneity of the product was checked by visually examining each herbal hair gel to make sure there were no lumps, flocculates, or aggregates present. The homogeneity for each formulation was determined to be adequate.
5. **Washability:**
   After applying the prepared herbal hair gel, it was rinsed with water. After washing, the gel is completely gone.
6. **Skin irritation:**
   After applying the prepared herbal hair gel to the hand's skin, it was left in the sun for four to five minutes. It was discovered to be non-irritating and skin-compatible.
7. **Stability studies:**
   For three months, stability tests were carried out on each formulation. At both room temperature and 40 °C, no discernible changes were seen in the evaluated parameters, such as appearance and pH.

CONCLUSION

The present study successfully formulated and evaluated an **herbal hair gel** using **flaxseed gel extract, curry leaves extract, and hibiscus extract**, aiming to provide a natural and effective alternative to synthetic hair care products. The **flaxseed gel** served as a natural gelling agent, offering hydration and nourishment, while **curry leaves extract** contributed antimicrobial and antioxidant properties. **Hibiscus extract**, known for its hair-strengthening and conditioning effects, further enhanced the formulation's efficacy. The **physicochemical evaluation** confirmed that the herbal hair gel exhibited **optimal pH, viscosity, spreadability, and stability**, ensuring its suitability for topical application. **Phytochemical analysis** revealed the presence of bioactive compounds such as flavonoids, tannins, and alkaloids, which are beneficial for scalp health and hair growth. The **DPPH assay** demonstrated **significant antioxidant activity**, indicating the gel's potential to protect hair from oxidative damage caused by environmental stressors. Overall, the formulated **herbal hair gel proved to be stable, antioxidant-rich, and beneficial for hair health**, making it a promising alternative to commercially available synthetic gels. The study highlights the **importance of herbal extracts in hair care formulations**, supporting their role in developing **safe, natural, and effective** cosmetic products.

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