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Ratanjot Hue: A Potential Natural Hair Dye Containing Alkanna Tinctoria

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Abstract

Herbal products are increasingly preferred over synthetic alternatives due to their safety and lack of harmful side effects caused by chemicals. Herbal hair dyes, particularly, have gained popularity because they effectively address the adverse effects associated with chemical-based dyes. The term "herbal" is often associated with safety and natural care. Hair discolouration occurs due to various factors such as genetics, environmental influences, and exposure to harsh substances like alcohol-based solutions. The natural hair shade is determined by the ratio of melanin pigments, including eumelanin and pheomelanin. This research focuses on the formulation of a herbal hair dye using extracts from natural ingredients, including Ratanjot, Henna, Mustard Oil, Tea Extract, Egg Yolk, and Lemon Juice. These ingredients provide vibrant colouring, deep conditioning, scalp nourishment, and exhibit antibacterial and antioxidant properties. Ratanjot (*Alkanna tinctoria*), a medicinal plant rich in alkannin, is the key ingredient responsible for the reddish-brown to deep burgundy colour. The prepared herbal hair dye was evaluated using various parameters, including organoleptic properties, physicochemical tests, dyeing effects, and patch testing to ensure safety and effectiveness.

Keywords: Herbal hair dye, Ratanjot, *Alkanna tinctoria*, antioxidant properties, scalp nourishment

1. INTRODUCTION

Hair colouring is a widely practiced method of changing hair colour, primarily for cosmetic reasons. It is used to cover grey or white hair, achieve trendy or desirable shades, or restore natural colour that has faded due to sunlight or hair treatments. Hair dyeing can also give the appearance of thicker, more voluminous hair. While semi-permanent dyes are often preferred for their gentle and temporary effects, many people still rely on chemical-based products, which can harm both hair and scalp.

In recent years, there has been a growing shift toward natural alternatives for beauty and wellness. Herbal hair dyes have emerged as a safer, eco-friendly option, free from harmful chemicals like ammonia and lead acetate. These dyes not only provide vibrant colouring but also nourish the hair and scalp, making them ideal for individuals seeking holistic hair care solutions.

Greying hair is a common concern, affecting nearly 70% of people over the age of 50 due to factors such as genetics, stress, nutritional deficiencies, and certain medical conditions. While chemical dyes are often used to address this issue, they can cause adverse effects like hair damage, skin irritation, and allergies. Prolonged use of chemical-based dyes has even been linked to serious health concerns, including cancer. Herbal hair dyes, on the other hand, are enriched with natural ingredients that contain beneficial compounds like tannins, which improve colour adherence and durability. Many natural dyes, such as those made with henna and plant-based additives, also condition and protect the hair. This study focuses on

developing a safe, effective, and ready-to-use herbal hair dye using plant-based ingredients, offering a sustainable alternative to conventional hair colouring methods.

1.1. Herbal hair dye:

Herbal hair dyes are a safe and natural alternative to chemical-based dyes, using plant-derived ingredients such as Ratanjot, Henna, Mustard Oil, Tea Extract, Egg Yolk, and Lemon Juice**.** Unlike chemical dyes that often contain harsh substances like ammonia and peroxide, herbal dyes are gentle on the scalp and hair. They help retain the hair's natural oils, promoting healthier and shinier locks. One of the main advantages of herbal hair dyes is their ability to create a range of shades, from vibrant reds to deep browns, depending on the combination of ingredients. For example, Ratanjot provides a reddish-burgundy tone, while Henna enhances colour depth and adds a natural shine. Beyond colouring, these dyes also offer conditioning benefits, with Egg Yolk and Mustard Oil nourishing the scalp and strengthening hair strands. Although herbal dyes may not provide the immediate intensity or long-lasting effects of chemical dyes, they fade gradually, resulting in a more natural and seamless transition between colours. Users can also customize their results by varying ingredient proportions or combining different herbal extracts, allowing for a personalized hair colouring experience. While lighter or dramatic colour changes may require multiple applications, herbal hair dyes remain a popular choice for individuals seeking to minimize chemical exposure and embrace the benefits of natural, botanical-based hair care.

1.2. Types of hair dye:

A. Temporary

Temporary hair dyes coat the surface of the hair without penetrating the strands or scalp.

These dyes can be easily washed out with just one shampoo.

Sometimes, temporary hair colouring is achieved using finely powdered metals applied through a spray (Puffer Spray).

Aqueous or hydro-alcoholic solutions containing simple dye agents are commonly used for this type of hair dye.

B. Semi-permanent

Semi-permanent dyes often contain compounds like **Nitro phenylene diamines**, **Nitroaminophenes**, or **Aminoanthraquinones**.

The effectiveness of these colourants can be enhanced by adding solvents.

These dyes primarily consist of cationic (positively charged) agents, which naturally bond with the hair, improving colour adherence and intensity.

C. Permanent

Permanent hair dyes are among the most popular products for long-lasting colour.

The dye is formed during the application process rather than being pre-mixed in the solution.

These systems can lighten the natural hair colour by using specific formulations.

They typically include key components like a dye intermediate and an oxidizing agent to achieve the desired colour.

1.3. Benefits of herbal hair dye:

Gentler on sensitive skin, these dyes lower the risk of irritation or allergic reactions.

They nourish the hair and scalp with natural vitamins and minerals, promoting healthier and stronger hair.

Made from plant-based ingredients, herbal hair dyes reduce exposure to harsh chemicals commonly found in synthetic dyes.

Herbal dyes fade gradually, creating a more natural look and minimizing the appearance of regrowth lines.

Ingredients like henna strengthen and thicken the hair shaft, reducing breakage and split ends.
Ideal for those seeking a holistic approach to hair care, herbal dyes align with natural and eco-friendly living.

1.4. Advantages of herbal hair dye:

Gentle on the scalp, reducing irritation and sensitivity.
Enriched with natural conditioning agents, leaving hair soft and shiny.
Eco-friendly and biodegradable, making it a sustainable choice.
Strengthens hair while promoting overall hair health.
Causes significantly less damage compared to chemical-based dyes.

1.5. Disadvantages of herbal hair dye:

Requires longer application and processing times.
Results may vary and can be less predictable.
The colour tends to fade faster compared to chemical dyes.
Can be more expensive than synthetic alternatives.
Offers fewer colour options and may not achieve drastic colour changes.

1.6. Uses of herbal hair dye:

Conditions and nourishes hair.
Promotes a healthier scalp.
Effectively covers grey hair.
Enhances hair shine and lustre.
Allows customization of hair shades.
Reduces scalp irritation compared to chemical-based dyes.

2. MATERIALS

2.1. Ratanjot

Figure 1: Ratanjot

- **Biological source:** Ratanjot, also known as *Alkanna tinctoria*, derives from the roots of the *Alkanna tinctoria* plant. This plant, commonly referred to as dyer's alkanet.
- **Family:** Boraginaceae.
- **Active constituents:** Alkannin, shikonin are the primary active constituents and it also contain terpenoids, flavonoids, tannins.
- **Uses**:
  - Traditionally used in medicine for its therapeutic properties.
  - Serves as a natural ingredient in culinary applications.
  - Widely utilized in cosmetics for colouring and skincare benefits.

2.2. Henna

Figure 2: Henna

- **Biological source:** It is obtained from the leaves of the plant *Lawsonia inermis*. These leaves contain a natural pigment called lawsone, which is responsible for the characteristic reddish-brown colour imparted by henna.
- **Family:** Lythraceae.
- **Active constituents:** Primary active constituent is lawsone and it also contains tannins, flavonoids, polysaccharides.
- **Uses**:
  - Functions as a natural colourant for hair and skin.
  - Acts as a hair conditioner, leaving hair soft and manageable.
  - Promotes healthy hair growth.
  - Contains antioxidant properties that protect hair from damage.

2.3. Mustard Oil

Figure 3: Mustard oil

- **Biological source**: Extracted from the seeds of *Brassica nigra* or *Brassica juncea*.
- **Family**: Brassicaceae.
- **Active constituents**: Contains essential fatty acids like oleic acid, linoleic acid, and erucic acid, along with vitamins E and K.
- **Uses**:
  - Acts as a natural conditioner, locking in moisture and adding shine to hair.
  - Strengthens hair strands and prevents breakage.
  - Stimulates the scalp and promotes hair growth.
  - Contains antibacterial properties, improving scalp health.

2.4. Tea Extract

Figure 4: Tea extract

- **Biological source**: Obtained from the leaves of *Camellia sinensis*.
- **Family**: Theaceae.
- **Active constituents**: Rich in polyphenols like catechins, tannins, flavonoids, and caffeine. Contains vitamins C and E.
- **Uses**:
  - Acts as a natural colour enhancer, imparting darker tones to hair.
  - Provides antioxidant properties that protect hair from environmental damage.
  - Strengthens hair roots, reducing hair fall.
  - Helps soothe the scalp and prevent dandruff.

2.5. Egg Yolk

Figure 5: Egg yolk

- **Biological source**: Derived from the yolk of eggs produced by *Gallus gallus domesticus* (domestic chicken).
- **Family**: Phasianidae.
- **Active constituents**: Rich in proteins, biotin, lecithin, fatty acids, and vitamins A, D, and E.
- **Uses**:
  - Acts as a natural conditioner, deeply moisturizing hair and improving texture.
  - Strengthens hair strands, reducing breakage and split ends.
  - Promotes healthy hair growth due to its protein content.
  - Nourishes the scalp, helping to maintain overall scalp health.

2.6. Lemon Juice

Figure 6: Lemon juice

- **Biological source**: Extracted from the fruit of *Citrus limon*.
- **Family**: Rutaceae.
- **Active constituents**: Contains citric acid, ascorbic acid (Vitamin C), flavonoids, and essential oils like limonene.
- **Uses**:
  - Acts as a natural astringent, cleansing the scalp and reducing excess oil.
  - Lightens hair colour slightly, adding subtle highlights.
  - Provides antioxidant protection, preventing oxidative damage to hair.
  - Promotes a healthy scalp by reducing dandruff and itchiness.

2.7. Lavender oil

Figure 7: Lavender oil

- **Biological source**: *Lavandula angustifolia* is an aromatic shrub with purple flowers, primarily used for its oil extracted from the flowers.
- **Family**: Lamiaceae.
- **Active constituents**: The active constituents of lavender oil include linalool, linalyl acetate, camphor, 1,8-cineole, and geraniol.
- **Uses**:
  - Promotes hair growth and helps reduce dandruff.
  - Enhances fragrance in perfumes and aromatherapy for a calming atmosphere which relieves stress and anxiety, promoting relaxation.
  - Heals and soothes skin, promoting wound healing and reducing scars.
  - Fights bacterial and fungal infections due to its antimicrobial properties.
  - Reduces inflammation and helps treat skin conditions like acne and eczema.

Formulation table:

Table 1: Formulation's Composition

Sr. No.	Ingredients (gm)	Uses	F1	F2	F3	F4	F5
1.	Ratanjot	Provides deep red-burgundy pigmentation.	5	15	10	15	15
2.	Henna	Maintains strong binding and colouring base.	10	10	10	-	-
3.	Beetroot extract	Enhances red tones and adds antioxidants.	7	-	-	10	-
4.	Mustard oil (ml)	For better scalp nourishment and shine.	-	10	15	5	-
5.	Castor oil (ml)	Helps moisturize and enhance shine.	12	-	-	5	-
6.	Coconut oil	For its moisturizing properties, it will help keep hair soft and hydrated.	-	-	-	-	12
7.	Lemon juice (ml)	Helps with colour enhancement and scalp cleansing.	-	2	1	-	2
8.	Vitamin E (ml)	Protects against oxidation and improves longevity.	2	-	1	2	2
9.	Tea extract	Strengthens hair and helps darken the dye.	7	-	6	6	6
10.	Coffee	Enhances dark brown tones for richer colour.	-	6	-	-	6
11.	Egg yolk	Acts as a natural conditioner and protein booster.	5	5	5	5	5
12.	Lavender oil (ml)	Provides a soothing fragrance and scalp benefits.	2	2	2	2	2

3. METHODOLOGY

Heat mustard oil on low flame and add Ratanjot powder. Stir continuously for 10-15 minutes. Now take henna powder and tea extract to the mix to form a smooth paste. Let it set for 5-6 hours to allow the dye colour to release. Gradually add the Ratanjot-infused oil to the henna paste while stirring. Add egg yolk as an emulsifying agent and mix well. Adjust pH with help of lemon juice. Add Vitamin E as preservative and Lavender oil as fragrance and aroma enhancer. Apply the paste to freshly washed hair and leave it for 4-5 hours before washing out for optimal results.

Figure 8: Solubility in various solvents

1-Alcohol
2-Mustard oil
3-Coconut oil
4-Organic phase

Figure 9: Soxhlet extraction

Figure 10: Extraction of Ratanjot

Figure 11: Mustard oil Ratanjot Extract

Figure 12: Beetroot extraction

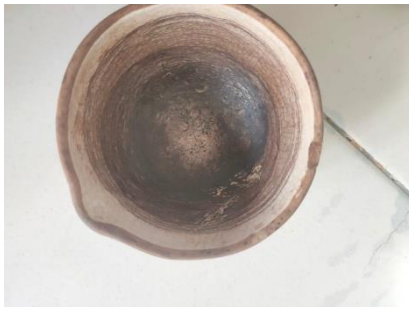

Figure 13: Ratanjot Extract

Figure 14: Application of Dye on Hair

Figure 15: Different Formulations

1-F1
2-F2
3-F3
4-F4
5-F5

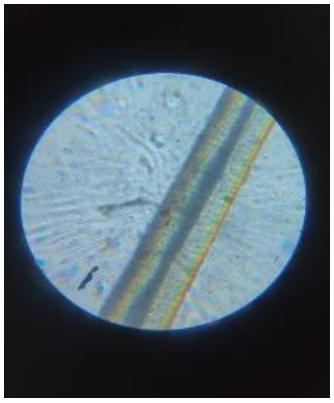

Figure 16: Hair before application of dye

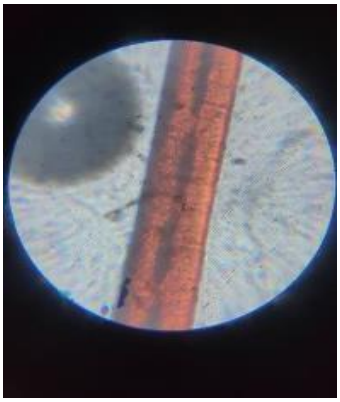

Figure 17: Hair after application of dye

4. EVALUATION TESTS

4.1. Physical evaluation

The herbal hair dye was evaluated using various parameters as follows:

4.1.1. Colour: The colour of the herbal hair dye formulation was visually observed, analyzed and noted.

4.1.2. Odour: The odour of the hair dye was assessed by sniffing it through nose.

4.1.3. Appearance: It was observed by visual inspection.

4.1.4. Texture: It was felt and assessed by touch manually.

4.2. Physicochemical assessment

4.2.1. pH: The dye was dissolved in water, and its pH was measured using a digital pH meter by dipping the electrode in the solution.

4.2.2. Loss on drying: The sample was heated at 105°C until it stopped losing weight to achieve a constant weight, used to determine moisture content.

4.2.3. Total ash value: The 2 gm of sample was burned in a crucible by gradually increasing the heat to 400°C until it turned white indicating absence of carbon, then cooled and total ash content was calculated.

4.2.4. Patch test: A small amount of the hair dye solution was applied behind the ear or on the inner elbow (1 cm^2 area) and left to dry. Any signs of irritation or discomfort were observed and recorded for 24 hours. The prepared herbal hair dye was applied for a set time, and symptoms like redness, swelling, or irritation were noted. Results showed it was safe and non-toxic.

4.3. Rheological evaluation

Measured powder flow properties, including bulk density, tapped density, angle of repose, Hausner's ratio, and Carr's index to check how well the powder settles and flows.

4.3.1. Angle of repose: Measured using a funnel to check how well the sample flows, calculated using a specific formula.

$\tan \theta = h/r$

where,

- θ = Angle of repose
- h= Height of heap
- r= Radius of the heap

4.3.2. Determination of bulk density and tapped density: The sample's volume (V1) was recorded in a cylinder as bulk volume, then tapped 100 times using a density apparatus and the final volume (V2) was noted as tapped volume.

Bulk Density = Mass/Bulk volume = W/ V1 g/ml

Tapped Density = Mass/Tapped volume = W/ V2 g/ml

4.3.3. Hausner's ratio: Measures how easily the powder flows, calculated using a specific formula.

Hausner's ratio = Tap density/Bulk density

4.3.4. Carr's index: Determines the powder's compressibility, calculated using a specific formula.

Carr's index = Tap density – Bulk density × 100 Tap density

4.4. Phytochemical evaluation

Various tests were conducted to identify the plant phytoconstituent compounds present in the products and their beneficial effects shown on the body. Every plant has certain phytochemical properties, which show several benefits.

4.4.1. Detection of carbohydrates

4.4.1.1. Molisch's Test: A few drops of alpha-naphthol solution in alcohol to 2-3 ml of aqueous extract, shake and concentrated H_2SO_4 were added to the extract from sides of the test tube; the formation of a violet ring at the junction of two liquids indicated the presence of carbohydrates.

4.4.1.2. Fehling's Test: Equal volumes of Fehling A and B solutions were mixed and heated, then equal amount of test solution was added. A yellow, followed by a brick-red precipitate, indicated the presence of reducing sugars.

4.4.2. Detection of alkaloids

4.4.2.1. Hager's test: Yellow precipitate forms when the filtrate is mixed with Hager's reagent.

4.4.2.2. Mayer's test: A creamy precipitate forms when the filtrate is mixed with Mayer's reagent.

4.4.3. Detection of proteins

4.4.3.1. Biuret test: Violet or pink colour appears when 4% NaOH and 1% $CuSO_4$ are added to the test solution.

4.4.4. Foam test: The drug extract is shaken with water, and persistent stable foam is observed.

4.4.5. Detection of terpenoids

4.4.5.1. Salkowski test: Mix the extract with chloroform and add a few drops of concentrated sulfuric acid. Shake gently which gives red or yellow color in the lower layer, indicating the presence of terpenoids.

4.4.6. Detection of glycosides

4.4.6.1. Keller-Killiani Test: Add glacial acetic acid, ferric chloride, and sulfuric acid to the extract, which forms brown ring at the interface of the two liquids, indicating the presence of glycosides.

5. RESULTS

Table 2: Physical evaluation

Sr. No.	Parameter	F1	F2	F3	F4	F5
1.	Colour	Brownish	Deep Burgundy	Reddish Brown	Light Reddish	Reddish
2.	Odour	Mild floral	Mild floral	Mild floral	Mild floral	Mild floral
3.	Appearance	Shiny	Shiny	Shiny	Shiny	Shiny
4.	Texture	Fine	Fine	Fine	Fine	Fine

Table 3: Physiochemical evaluation

Sr. No.	Parameter	F1	F2	F3	F4	F5
1.	pH	6.6	6.5	6.7	6.6	6.8
2.	Loss on drying	8.2%	8.8%	8.0%	8.5%	7.9%
3.	Total ash value	3.5%	3.8%	3.3%	3.6%	3.4%

Table 4: Patch test

Sr. No.	Parameter	F1	F2	F3	F4	F5
1.	Swelling	Negative	Negative	Negative	Negative	Negative
2.	Redness	Negative	Negative	Negative	Negative	Negative
3.	Irritation	Negative	Negative	Negative	Negative	Negative

Table 5: Rheological evaluation

Sr. No.	Parameter	F1	F2	F3	F4	F5
1.	Bulk density	0.42	0.45	0.44	0.43	0.46
2.	Tapped density	0.55	0.58	0.57	0.56	0.59
3.	Angle of Repose	32.2	30.6	31.3	33.7	29.5
4.	Carr's index	23.6	22.4	22.8	23.2	22.0
5.	Hausner's ratio	1.31	1.29	1.30	1.30	1.28

Table 6: Phytochemical evaluation

Sr. No.	Parameter	F1	F2	F3	F4	F5
1.	Molisch's Test	+ve	+ve	+ve	+ve	+ve
2.	Fehling's Test	-ve	-ve	-ve	-ve	-ve

3.	Hager's test	+ve	+ve	+ve	+ve	+ve
4.	Mayer's test	+ve	+ve	+ve	+ve	+ve
5.	Biuret test	+ve	+ve	+ve	+ve	+ve
6.	Foam test	-ve	-ve	-ve	-ve	-ve
7.	Salkowski test	+ve	+ve	+ve	+ve	+ve
8.	Keller-Killiani Test	+ve	-ve	+ve	+ve	+ve

6. CONCLUSION

In conclusion, the formulation F3 demonstrated the most efficient performance among all tested formulations. It exhibited optimal pH balance (6.7), the lowest loss on drying (8.0%), and the lowest total ash value (3.3%), indicating better stability and effectiveness. Additionally, F3 maintained a deep burgundy color with a mild floral odor, shiny appearance, and fine texture, making it visually and texturally appealing. The patch test results confirmed that F3 was safe for use, showing no signs of irritation, redness, or swelling. Furthermore, its rheological evaluation indicated good flow properties with a Hausner's ratio of 1.30 and Carr's index of 22.8, ensuring ease of application. Finally, herbal hair dye formulations provide a natural and safer alternative to chemical-based dyes, with F3 standing out as the most efficient formulation due to its stability, coloring properties, and user safety. This research supports the growing preference for herbal hair dyes as a sustainable and effective solution for hair coloring and scalp nourishment.

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