IJPPR
INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH
An official Publication of Human Journals
ISSN 2349-7203
HUMAN

Human Journals
**Research Article**
May 2024 Vol.:30, Issue:5


# Formulation and Evaluation of Polyherbal Natural Hair Coloring

IJPPR
INTERNATIONAL JOURNAL OF PHARMACY & PHARMACEUTICAL RESEARCH
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ISSN 2349-7203
HUMAN

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**Submitted:** 27 April 2024
**Accepted:** 02 May 2024
**Published:** 30 May 2024



**Keywords:** Hair dye, indigo, beetroot, Fenugreek, formulation, evaluation

**ABSTRACT**

Hair care products, such as hair dye, are crucial for maintaining and improving the appearance and health of hair. Most commercial hair colors contain toxic ingredients that can irritate the scalp or cause allergic reactions. This study aims to develop and evaluate a polyherbal hair dye powder in various shades using herbs. The selected plants were shade-dried and tested for microbiological and physical stability through expedited stability studies. The formulations, F1, F2, and F3, demonstrated superior color intensity and staining properties without physical or microbiological contamination. The natural ingredients ensure minimal adverse effects, making the product suitable for people of all ages and ethnicities.

## INTRODUCTION

Ever since the dawn of civilization, people have been drawn to the allure of impressing others with their appearance. There were no sophisticated fairness creams or cosmetic surgery procedures in the past. Originally, humans only had access to natural knowledge, which was compiled into Ayurveda. The same excellent resources are available for Ayurvedic cosmetics, commonly referred to as herbal cosmetics, in the modern era[1]. Topical medicines called "cosmeceuticals" that combine pharmacological and cosmetic elements to improve appearance while also offering extra health advantages are known as "cosmeceuticals." Thus, these goods act as a bridge between medications and personal care items, the latter of which are created especially for medical and cosmetic uses. With the promising attention to revise the traditional scheme and to utilize their potentials which are based on different health care systems, the evaluation of the rich custom of the traditional medicines or herbs is essential[2]. Nowadays, herbal measures are employed to intensify beauty and augment the charm of the person. A global scenario is changing towards the use of safer, nontoxic and traditionally used natural products. Herbal hair preparations can be worn in various disorders such as alopecia (hair loss), dandruff, premature graying and head lice etc. Screening grey hair or modifying natural hair color has been increased to great extent nowadays. Human hair plays an imperative role in enhancing appearance and looks. Baldness and hair graying are problems with 60 to 70% of people. People begin to have gray hairs when they have a vitamin B12 deficiency, thyroid conditions, or genetic or heredity issues[3]. Adults are mostly at risk of early depigmentation due to conditions like illness, UV radiation, stress, alcohol use, some medications, shock, and more. Hair coloring or dying refers to practices of changing of the hair color. Regaining white and grey hair, changing the natural color to something more stylish or appealing, or restoring the original color after sun bleaching or hair coloring has stained the hair are the primary motivations for this4. The most noticeable human trait is hair color. Nowadays people are very much conscious about their looks. Graying/whitening of hair is natural process of human aging. Grey /white hair develops naturally or prematurely in the process of human aging due to progressive and ultimate total loss of melanocyte in the hair follicle. Hair with no melanin pigments in cortex is utterly white and with little pigments shows grey colour. Due to ever increasing problem of premature graying (PHG) the hair dyes are used periodically for beautiful and younger look[5].Numerous factors, including heredity, stress, illness, and malnutrition, can cause graying of the hair. About half of the world's population will have 50% gray hair by the age

of fifty, with genetics being the main cause of premature graying. As a result, hair color is in high demand right now. Natural colors are made without the use of chemicals from plant, animal, or insect materials. Natural hair dye is currently more popular than chemical-based dye, which can result in a number of skin-related problems. The demand for herbal hair dye based on natural components is rising quickly because of its beneficial properties and lack of harmful or adverse effects. The markets artificial or synthetic hair dyes contain a combination of ammonia, peroxide, or PPD, which damages hair and can also trigger allergies[6].

**HAIR DYE**

Recent studies have revealed that hair coloring was practiced by the Egyptians, Greeks, and Romans thousands of years ago. Before the development of contemporary dyes, a wide variety of plant extracts were utilized in Europe and Asia for hair coloring. There are three varieties of hair color available: semi-permanent, permanent, and temporary. Hair coloring is an age-old craft that entails treating hair with different chemical compounds. In ancient Greece, hair was treated with a variety of ointment prepared of pollen and yellow flower petals after being bleached with a potassium solution rinse. These days, many prefer natural herbal hair dyes over chemical-based ones that might lead to skin conditions and other skin-related illnesses. Herbal medications are utilized for healthy hair and have no side effects. Because herbal medicines are naturally good and have no negative effects, demand for them is raising quickly[7].

**Advantage**

- No mess or hair color stains on your skin.
- Using herbal hair color is one of the best quick fixes without any side effects.
- This hair dye will help you strengthen your hair and keep your hair protected from chemicals throughout the procedure.
- If you want soft and silky-colored hair, this is the best option[8].
- It is usable by equally men and women.

**Disadvantages**

- Herbal drugs have weaker efficiency as contrast to allopathic dosage forms.
- It requires long tenure therapy.
- They are intricate to cover taste & odor.

- Manufacturing process is time consumingϖ& complicated.
- There is no pharmacopoeia that specifies the usage of any particular method or component in herbal cosmetics[9].

## MATERIAL AND METHOD

### Collection of plant material

The following plant materials were collected from a garden and authenticated by a botanist. The materials were dried in shade and powdered.

### Collection of unpigmented hair

Human hair was gathered from a barbershop, with white hair segregated for research[10].

**Table 1: List of various herbal crude drugs used to prepare the formulations**

| Sr. No. | Drug with common name and description | Image | Use |
|---|---|---|---|
| 1- | Indigo powder- True indigo or nil, obtained from leaves of *Indigofera tinctoria* |  | Coloring agent, encourage hair growth[11] |
| 2- | Fenugreek- Methi<br>Consist of dried seeds of plant *Trigonella foenum.*<br>Family- Fabaceae |  | Hair growth promoter[12] |
| 3- | Orange peel- It consists of fresh fruits of plant *Citrus aurantarium*.<br>Family: Rutaceae |  | Hair growth promoter[13] |
| 4- | Peppermint- *Mentha piperata* is a powerfully scented perennial herb<br>Family-Labiatae |  | Hair growth promoter, improve scalp[14]. |
| 5- | Marigold- It consists of flowers and petals of *Tagetes erecta*<br>Family - Asteraceae |  | Improve hair health, boost hair growth[15] |

| | | | |
|---|---|---|---|
| **6-** | Custard apple seeds<br>Sharifa, sitaphal, sugar apple<br>It consists of dried seeds of *Annona squamosa*<br>Family- Annonaceae |  | Anti-lice agent, prevent premature graying[16] |
| **7-** | Banana peel<br>It consist of fruit of *Musa acuminata*<br>Family- Musaceae |  | Provide shine to hair and strengthen hair and improve hair health[17] |
| **8-** | Coffee<br>It consists of dried ripe seeds of *Coffea arabica*<br>Family- Rubiaceae |  | Reduce hair loss and encourage hair growth, darken hair[18] |
| **9-** | Beetroot<br>It consist of *Beta vulgaris*<br>Family- chenopodiaceae |  | Reduces hair breakage, nourishes hair follicles, and helps to delay premature graying[19]. |
| **10-** | Cinnamon<br>It consists of dried inner bark of shoot of tree *Cinnamomum zeylanicum*<br>Family- Lauraceae |  | Possess anti fungal properties, stimulate circulation, encourage hair growth and reduce hair loss[20] |
| **11-** | Black sesame, Kaale til<br>It consists of seeds of *Sesamum indicum*<br>Family- Pedaliaceae |  | Strengthen hair follicles, improve hair health, promote hair growth, and stimulate melanocyte activity[21]. |
| **12-** | Black seed- Kalonji<br>It consists of seeds of *Nigella sativa*<br>Family- Ranunculaceae |  | Minimizes dandruff, moisturizes hair, soothes scalp dryness, and prevents graying[22]. |
| **13-** | Turmeric- Haldi<br>It consists of dried rhizomes of *Curcuma longa*<br>Family- Zingiberaceae |  | Thickens hair, stimulate hair growth, anti bacterial in nature ,promote hair growth[23] |
| **14-** | Rose<br>It consists of flowers and petals of *Rosa hybrida*<br>Family- Rosaceae |  | Conditions hair, nourishes the scalp, reduces dandruff , promotes hair growth[24] |

**Size Reduction of Dried Plants**

The herbs were ground using a mortar and pestle, sieved for uniformity, and weighed using an analytical balance.

**Formulation studies**

The prepared herbal powder hair dye contains all the integrity of natural ingredients. Apart from performing as a hair dye, this formulation also acts as a hair growth enhancer, nourishes, conditioner and anti-dandruff agent. Three different herbal hair dye formulations were prepared using various herbal ingredients such ingredients like indigo, beetroot, fenugreek, coffee, black sesame, black seeds, turmeric, and cinnamon. The ingredients were pulverized, weighed, and mixed uniformly to form a powder dye[25].

**Figure 1: Various types of herbs used for formulation**

**Application of hair dye**

The powder dye can be applied on dry hairs by making a paste in water with most favorable consistency. It should be applied uniformly on the hair with the aid of a brush, casing the roots to the hair tip. The scalp should be enclosed evenly. It should be left for 2-3 hours on the scalp for complete drying. Then it should be rinsed thoroughly with running water[26].

**CHARACTERIZATION OF THE HAIR COLORANT FORMULATIONS**

The prepared poly herbal powdered hair dye was evaluated for various parameters, such as organoleptic, physiochemical, phytochemical constituents and the powdered characteristics.

**Organoleptic evaluation:** Organoleptic characteristics for various sensory characters like color, taste, odor, appearance, texture were carefully observed[27].

**Microscopic studies:** Microscopic examination of colored hair was examined by means of microscope.

## PHYSICOCHEMICAL EVALUATION

The physical and chemical properties of the poly herbal powdered hair dye were evaluated to verify the pH, its moisture content and its ash value for the purpose of stability, compatibility and the quantity of inorganic substance present in it.

- **pH:** Employing a calibrated electronic pH meter, the formulation's aqueous solution's pH was determined.

- **Loss on drying:** Weigh the medication powder in a porcelain dish to a weight of around 1.5 grams. Dry at either 100°C or 105°C in the oven. Until there is a 0.5gm difference in two consecutive weight readings. Weigh after cooling the desiccators. Usually, the weight loss is reported as moisture.

- **Ash content:** In a crucible that has already been fired and tared, add around 2-4 grams of freshly air dried material, weigh it precisely, spread it out evenly, and light it by gradually raising the heat to 500–600 degrees Celsius before it turns white. If the carbon-free ash cannot be obtained in this way, cool the crucible, soak the residue with about two milliliters of water or a saturated solution of ammonium nitrate, dehydrated on a water bath, followed by a hot plate and ignite to constant weight. This indicates the absence of carbon. Weigh. After letting the residue cool in an appropriate desiccators for 30 minutes, weigh it right away to determine the amount of total ash in milligrams per gram of air-dried materiall[28, 29].

### Evaluation Testing for the Finished Product

Evaluation testing for the finished product was done using cotton fiber and human white strands to determine the dyeing efficiency in requisites of colour intensity.

### Study on Dyeing Effect

The formulated dyes were kept side by side for 1 hour and then the cotton samples were kept for 1 hour to 2 hours for all the different shades of cotton dye formulations for their dyeing effect.

### Evaluation Using Human Hair

The prepared formulation was studied for dyeing efficiency, which will be on human white strands. Dyeing efficiency was demonstrated in terms of colour grade. 0.33gm of herbal hair dye was examined to human white strands. Then, the dyed white hair was washed with tap

water after 2 hours. Followed by the second coating of the dye that needs to be applied after 24 hours of the first application and was kept for 2 hours and was washed again with tap water without the aid of shampoo[30].

**TESTS FOR POWDERED CHARACTERISTICS:**

**Rheological evaluation**

Physical parameter like bulk density, tapped density, the angle of repose, Hausner's ratio and Carr's index were observed and noted down.

**a. Bulk density:** The ratio of a powder's given mass to its bulk volume is known as its bulk density. The necessary amount of powder is dried and then added to a 50 ml measuring cylinder until it reaches the 50 ml mark. The cylinder is then dropped, two seconds apart, from a height of one inch onto a hard wood surface. It is measured how much powder there is. The powder is then weighed. Repeating this yields average results. Precisely weigh 10 grams of powder, and then transfer it to a 50 milliliter measuring cylinder. Read the unclear seeming value without compacting or pressing the powder combination[31].

Bulk density = Bulk mass / Bulk volume

**b. Tapped density:** It is obtained by mechanically tapping a powder sample container. Following the initial observation of the powder volume or mass, the measuring cylinder or vessel is mechanically tapped for one minute, during which time readings of the volume or mass are taken until minimal variations in the volume or mass are noted. The unit of measurement was grams per millimeter. Weigh 10 grams of powder precisely, then transfer it to a 50 milliliter measuring cylinder and tap it 100 times in three sets.

Tapped Density = Mass / Tapped volume

**c. % Carr's index:**

% Weight Carr's index = (Tapped Density – Bulk density)/ tapped density *100

**d. Hausner's ratio**

Hausner's Ratio = Tapped density /Bulk density

**e. Angle of repose:** It is defined as the maximum angle achievable in between the surface of pile of powder to the horizontal flow. Required quantity of dried residue is positioned in a cylinder tube open at both ends is located on a horizontal surface. Then the funnel should be

removed to structure a heap. The height and radius of heap is illustrated and recorded. For the above method, the angle of repose can be considered by using formula. Angle of repose was determined by funnel method[32].

$$\text{Angle of repose} = \tan^{-1}h/r$$

Where, θ - Angle of repose, h - Height of the heap, and r – Radius of the base

**Patch test**

This test usually involves application of small amount of aqueous solution of herbal dye at the back of ear or on internal elbow in an area of 1sq.cm and leaving it until it dries. It was applied for a fixed interval of time and any sign of redness; itching or any feeling of uneasiness was observed at regular intervals up to 24 hours[29].

**Stability studies**

Formulation and development of a pharmaceutical product is not complete without proper stability analysis carried out on it to determine physical and chemical stability and thus safety of the product. The prepared formulations were stored at different storage conditions of temperatures such as cold temperature, cool temperature, and at room temperature[30].

***In Vitro* and *In Situ* Studies for Finalized Hair Dye Formulation**

*In vitro* and *in situ* testing was done for the herbal hair dye formulations. *In vitro*, testing was done on the cotton while *in situ* testing was done on human white hair. The stains obtained on the cotton and hair samples were almost the same[32].

**RESULTS AND DISCUSSIONS**

For the preparation of herbal hair dye we used different herbs as mentioned in the formula-

**Figure 2: Final formulation of hair coloring**

**Table 2: Formulation 1 (F1): Indigo hair dye**

| Sr No. | Ingredients | Quantity |
|---|---|---|
| 1. | Indigo powder | 15 gm |
| 2. | Turmeric powder | 5gm |
| 3. | Custard apple seeds | 3gm |
| 4. | Peppermint powder | 5gm |
| 5. | Orange peel powder | 6gm |
| 6. | Banana peel powder | 6gm |
| 7. | Marigold and rose | 5gm |
| 8. | Cinnamon powder | 5gm |

**Table 3: Formulation 2 (F2): Fenugreek (black hair dye)**

| Sr No. | Ingredients | Quantity |
|---|---|---|
| 1. | Fenugreek powder | gm |
| 2. | Coffee powder | 4.5gm |
| 3. | Custard apple seeds | 3gm |
| 4. | Peppermint powder | 3gm |
| 5. | Orange peel powder | 5gm |
| 6. | Banana peel powder | 5gm |
| 7. | Marigold and rose | 5gm |
| 8. | Cinnamon powder | 5gm |

**Table 4: Formulation 3 (F3): Beetroot hair dye (red hair dye)**

| Sr No. | Ingredients | Quantity |
|---|---|---|
| 1. | Beetroot powder | 15 gm |
| 2. | Turmeric powder | 5gm |
| 3. | Custard apple seeds | 3gm |
| 4. | Peppermint powder | 5gm |
| 5. | Orange peel powder | 6gm |
| 6. | Banana peel powder | 6gm |
| 7. | Marigold and rose | 5gm |
| 8. | Cinnamon powder | 5gm |

**Organoleptic Evaluation**

Various physical parameters such as color, odor, texture, pH, and appearance of herbal hair dye were evaluated, and the results were summarized in Table 5.

**Table 5: Organoleptic evaluation of three herbal formulation**

| Sr No. | Parameters | Formulation 1 | Formulation 2 | Formulation 3 |
|---|---|---|---|---|
| **1.** | Color | Earthy green | Yellowish -brown | Reddish brown |
| **2.** | Odor | Characteristic | Characteristic | Characteristic |
| **3.** | Texture | Smooth and fine | Slightly smooth | Slightly smooth and fine |
| **4.** | Appearance | Homogenous powder | Homogenous powder | Homogenous powder |

**Physicochemical Evaluation**

The physical and chemical properties of the polyherbal powdered hair dye were evaluated to verify stability, compatibility, and the presence of inorganic substances.

**Table 6: Physicochemical evaluation**

| S.No. | Parameters | F1 | F2 | F3 |
|---|---|---|---|---|
| **1.** | pH | 6.4 | 6.8 | 6.5 |
| **2.** | LOD | 1.6%w/w | 1.9%w/w | 1.7%w/w |
| **3.** | Ash value | 0.18%w/w | 0.17%w/w | 0.16%w/w |

**Test for Powdered Characteristics**

Physical parameters like bulk density, tapped density, the angle of repose, Hausner's ratio, and Carr's index were observed.

**Table 7: Test for powdered characteristics**

| Sr No. | Flow Property | Formulation 1 | Formulation 2 | Formulation 3 |
|---|---|---|---|---|
| 1 | Bulk density | 0.33 gm/ml | 0.34 gm/ml | 0.36 gm/ml |
| 2 | Tapped density | 0.49 gm/ml | 0.57 gm/ml | 0.5 gm/ml |
| 3 | Carr's index | 30.22% | 25.3% | 28% |
| 4 | Hausner's ratio | 1.45 | 1.25 | 1.38 |
| 5 | Angle of repose | 22.36º | 24.56º | 26.23º |

**Patch test**

The herbal hair dye samples were subjected to patch test since herbal hair dye should not produce any skin sensitization or irritation when applied on hair. All the herbal formulation does not show any irritation. All the formulations are completely free from irritation.

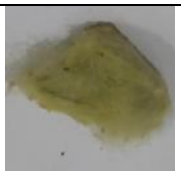
**Table 8: Patch test observes after 48 hours for irritation or redness, swelling.**

| Sr. No. | Parameter | Formulation 1 | Formulation 2 | Formulation 3 |
|---|---|---|---|---|
| 1 | Swelling | Negative | Negative | Negative |
| 2 | Redness | Negative | Negative | Negative |
| 3 | Irritation | Negative | Negative | Negative |

**Table 9: Stability evaluation after one month**

| Sr. No. | Parameters | Formulation | Room temp. | 35oC 65%RH | 40oC 75%RH |
|---|---|---|---|---|---|
| **1** | Color | F1<br>F2<br>F3 | No variation<br>No variation<br>No variation | No variation<br>No variation<br>No variation | No variation<br>No variation<br>No variation |
| **2** | Odor | F1<br>F2<br>F3 | No variation<br>No variation<br>No variation | No variation<br>Slight variation<br>No variation | No variation<br>No variation<br>No variation |
| **3** | pH | F1<br>F2<br>F3 | No variation<br>Slight variation<br>No variation | No variation<br>No variation<br>No variation | No variation<br>Slight variation<br>No variation |
| **4** | Texture | F1<br>F2<br>F3 | No variation<br>No variation<br>No variation | No variation<br>No variation<br>No variation | No variation<br>No variation<br>No variation |
| **5** | Smoothness | F1<br>F2<br>F3 | No variation<br>Slight variation<br>No variation | No variation<br>No variation<br>Slight variation | No variation<br>Slight variation<br>No variation |

**Table 10. In vitro studies of formulated hair dye after wash**

| Sample No. | Cotton | Hair Sample | Shade of Hair Dye |
|---|---|---|---|
| **F1** |  |  | Indigo hair dye |
| **F2** |  |  | Black hair dye |
| **F3** |  |  | Red hair dye |

## CONCLUSION

Herbal hair dye formulation contains only natural ingredients and is made in a simple process. The formulation appears to be smooth and pleasant smelling, based on organoleptic evaluation parameters. The pH was found to be neutral to meet the needs of different scalp types, according to physicochemical parameters. The ash value was found to be within acceptable limits, indicating the presence of appropriate amounts of inorganic radicals. This study successfully formulated and evaluated polyherbal hair dyes using natural ingredients, demonstrating superior color intensity, stability, and minimal adverse effects. The formulations are suitable for all age groups and ethnicities, providing a safe alternative to chemical-based hair dyes. Future research could focus on further improving the dyeing efficiency and exploring additional natural ingredients. As this preparation does not require sophisticated instrument so it can benefit to small industries, start-up, and human being in terms of cost as well as benefit of application and definitely it will bring a change in cosmetic industry.

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