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Research Article

Formulation and Evaluation of a Polyherbal Hair Dye using *Phyllanthus reticulatus* Fruit

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ABSTRACT

The increasing use of synthetic hair dyes containing ammonia, hydrogen peroxide, and para-phenylenediamine has raised serious health concerns, including scalp irritation, allergic reactions, and hair damage. This has led to growing interest in herbal alternatives that are safer and environmentally friendly. The present study focuses on the formulation and evaluation of a polyherbal hair dye using *Phyllanthus reticulatus* fruit as the primary natural colouring agent. The fruit extract, rich in tannins, flavonoids, and phenolic compounds, was combined with other herbal ingredients such as *Hibiscus rosa-sinensis*, *Lawsonia inermis*, and *Embllica officinalis* to enhance colouring efficiency and conditioning properties. The formulated dye was evaluated for organoleptic characteristics, physicochemical parameters, pH, spreadability, stability, washability, and safety through patch testing. The results showed satisfactory colour deposition, good stability, and compatibility with scalp pH without causing irritation. Additionally, the formulation exhibited antioxidant and antimicrobial properties beneficial for scalp health. The study concludes that the developed polyherbal hair dye is a safe, effective, eco-friendly, and economical alternative to synthetic hair dyes with added therapeutic benefits.

INTRODUCTION

Herbal hair dye is a natural cosmetic preparation used to colour the hair using plant-based ingredients. It contains botanical extracts that help in colouring, nourishing, and protecting the hair. Unlike synthetic hair dyes that contain harmful chemicals such as ammonia, hydrogen peroxide,

and para-phenylenediamine, herbal hair dyes use natural ingredients and are safer for regular use. Herbal hair dyes not only provide colour but also improve hair health, strengthen hair, and protect the scalp. These herbal preparations are rich in natural colouring agents such as tannins, flavonoids, and phenolic compounds, which help

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in colouring the hair naturally without damaging its structure.

One such important plant used in herbal hair dye is *Phyllanthus reticulatus*, which belongs to the family *Phyllanthaceae*. The fruits of this plant contain natural colouring pigments that help in colouring the hair. The plant also possesses antioxidant, antimicrobial, and medicinal properties which help in maintaining healthy hair and scalp.

Polyherbal hair dye is a preparation containing more than one herbal ingredient to improve effectiveness. Common herbal ingredients used include henna, hibiscus, and amla, which help in better colouring, conditioning, and strengthening the hair.[1]

Natural ingredients: Common ingredients include *phyllanthus rectus*, *hibiscus*, *Lawsonia inermis*, *Eclipta Prostrata*, *Embllica officinalis*, *Vitex Negundo*, *Surma Stone* (Tutty / Tutia).

Hair and Scalp Benefits:

Many herbal ingredients have:

- Antioxidant properties
- Antimicrobial properties
- Hair strengthening activity
- Hair growth promoting activity

These properties help maintain healthy hair and scalp.

Colouring and Conditioning Property:

Herbal hair dyes help to:

- Provide natural colour to hair

- Improve hair texture
- Increase hair shine
- Reduce hair damage

Safe and Eco-friendly:

Herbal hair dyes are:

- Free from harmful chemicals
- Safe for regular use
- Eco-friendly
- Cost effective

Functions of Herbal Hair Dye:

1. Colours the hair naturally
2. Improves hair appearance
3. Protects hair from damage
4. Improves hair strength
5. Maintains scalp health

Advantages of Herbal Hair Dye:

1. Safe to use
2. No side effects
3. Improves hair quality
4. Economical
5. Eco-friendly

Disadvantages of Synthetic Hair Dye:

1. Causes hair damage
2. Causes scalp irritation



3. Causes allergic reactions

4. Weakens hair

5. Harmful for long-term use[2]

Characteristics of Herbal Hair Dye

An ideal herbal hair dye should possess good colouring ability and provide uniform colour to the hair without causing any damage. It should be safe, non-toxic, and free from harmful chemicals so that it does not cause scalp irritation, allergy, or hair fall. The hair dye should have good stability and should remain effective during storage. It should be easy to apply and spread uniformly on the hair. The formulation should have suitable consistency and should not be too thick or too thin. It should also have good washability and should retain colour on the hair for a longer period. In addition to colouring, the herbal hair dye should provide conditioning effect, improve hair texture, increase shine, and maintain scalp health. It should be economical, eco-friendly, and acceptable in terms of colour, odour, and appearance.[3]

PLANT PROFILE:

1. Phyllanthus reticulatus



Figure1 : Image of Phyllanthus reticulatus

Scientific name: Phyllanthus reticulatus

Family: Phyllanthaceae

Synonyms:

- Black honey shrub
- Pancoli
- Karinelli

Chemical constituents:

- Tannins
- Flavonoids
- Alkaloids
- Phenolic compounds
- Glycosides

Uses:

- Used as natural hair colouring agent
- Provides black colour to hair
- Has antioxidant property
- Maintains scalp health

2. Hibiscus



Figure2 : Image of Hibiscus

Scientific name: Hibiscus rosa-sinensis

Family: Malvaceae

Synonyms:

- China rose
- Shoe flower

Chemical constituents:

- Flavonoids
- Anthocyanins
- Vitamin C
- Tannins

Uses:

- Promotes hair growth
- Improves hair shine
- Conditions hair
- Prevents hair damage[4]

3. Lawsonia inermis



Figure 3: Lawsonia inermis

Scientific name: Lawsonia inermis

Family: Lythraceae

Synonyms:

- Henna
- Mehndi

Chemical constituents:

- Lawsone
- Tannins
- Flavonoids

Uses:

- Natural colouring agent
- Provides reddish colour
- Strengthens hair
- Prevents hair fall

4. Eclipta prostrata



Figure 4: Image of Eclipta prostrata

Scientific name: Eclipta prostrata

Family: Asteraceae

Synonyms:

- Bhringraj
- False daisy

Chemical constituents:

- Wedelolactone
- Alkaloids
- Flavonoids

Uses:

- Promotes hair growth
- Prevents greying
- Strengthens hair

5. Emblica officinalis



Figure 5: Image of Embelica officinalis

Scientific name: Emblica officinalis

Family: Phyllanthaceae

Synonyms:

- Amla
- Indian gooseberry

Chemical constituents:

- Vitamin C
- Tannins
- Flavonoids

Uses:

- Prevents hair greying
- Strengthens hair
- Improves hair growth[5]

6. Vitex negundo



Figure 6 : Image of Vitex negundo

Scientific name: Vitex negundo

Family: Verbenaceae

Synonyms:

- Nirgundi
- Five leaved chaste tree

Chemical constituents:

- Flavonoids
- Alkaloids
- Essential oils

Uses:

- Prevents scalp infection
- Improves scalp health
- Promotes hair growth

7. Surma Stone (Tutty / Tutia)



Figure 7: Image of Surma stone

Scientific name: Zinc oxide (mineral origin)

Synonyms:

- Tutty
- Tutia
- Surma stone

Chemical constituents:

Zinc oxide

Uses:

- Improves colour intensity
- Acts as colouring agent
- Enhances dye stability

EXCIPIENT PROFILE :

1. Ethanol

Type: Solvent

Role: Used as extraction solvent and helps dissolve active constituents.

Description: Ethanol is a clear, colourless, volatile liquid with characteristic odour. It is

widely used in pharmaceutical and cosmetic formulations.[6]

IUPAC Name: Ethanol

Chemical Formula: C_2H_6O

Chemical Structure:

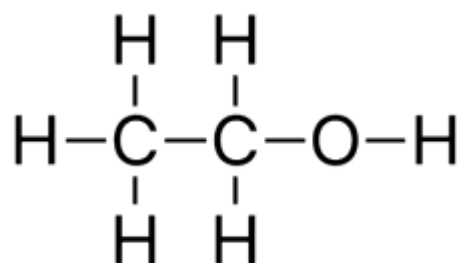


Figure 8: Structure of ethanol

2. Propylene Glycol

Type: Humectant and Solvent

Role: Helps retain moisture and improves penetration of ingredients.

Description: It is a clear, colourless, viscous liquid used in cosmetic preparations.

IUPAC Name: Propane-1,2-diol

Chemical Formula: $C_3H_8O_2$

Chemical Structure:

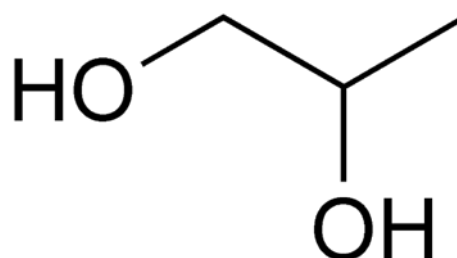


Figure 9: Structure of propylene glycol

3. PVP K30

Type: Binder and Film-forming agent

Role: Helps in binding and improves stability of formulation.

Description: It is a white hygroscopic powder soluble in water and alcohol.[7]

IUPAC Name: Poly(1-vinylpyrrolidin-2-one)

Chemical Formula: $(C_5H_7NO)_n$

Chemical Structure:

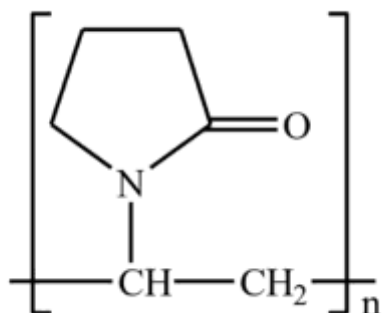


Figure 10: Structure of PVP K 30

4. Glycerin

Type: Humectant

Role: Provides moisture and softness to hair.

Description: It is a clear, colourless, viscous liquid with sweet taste.[8]

IUPAC Name: Propane-1,2,3-triol

Chemical Formula: $C_3H_8O_3$

Chemical Structure:

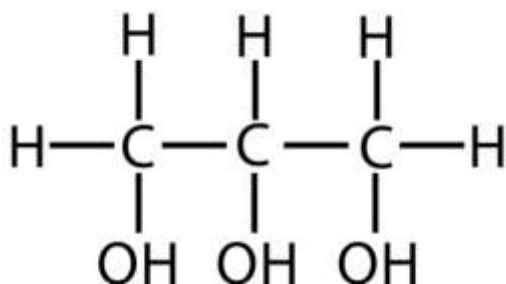


Figure 11: Structure of Glycerin

5. Xanthan Gum

Type: Thickening agent

Role: Provides viscosity and stability to formulation.

Description: It is a cream coloured powder soluble in water.[9]

IUPAC Name: Polysaccharide (Xanthan)

Chemical Formula: $(C_{35}H_{49}O_{29})_n$

Chemical Structure:

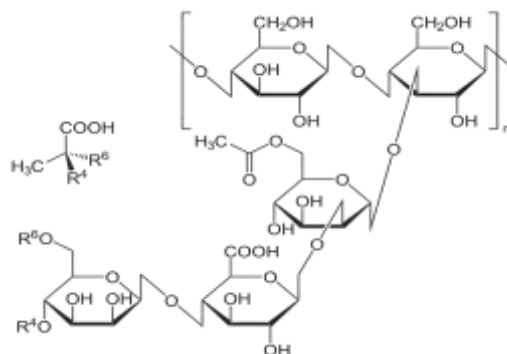


Figure 12: Structure of Xanthum gum

6. Phenoxy Ethanol

Type: Preservative

Role: Prevents microbial growth.

Description: It is a colourless oily liquid used as preservative.[10]

IUPAC Name: 2-Phenoxyethanol

Chemical Formula: $C_8H_{10}O_2$

Chemical Structure:

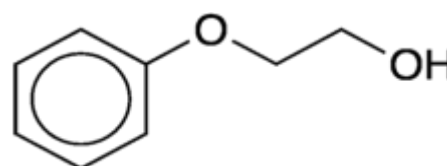


Figure 13: Structure of Phenoxy ethanol

MATERIALS AND METHODS:

Table 1: Formulation Table

Sr. No	Ingredients	Quantity	Role
1	Phyllanthus reticulatus	50 g	Main colouring agent
2	Hibiscus rosa-sinensis	10 g	Pigment intensifier and conditioner
3	Lawsonia inermis	10 g	Natural dye pigment
4	Eclipta prostrata	10 g	Dark colour enhancer
5	Emblica officinalis	10 g	Hair conditioner
6	Vitex negundo	10 g	Scalp conditioning agent
7	Surma stone (Tutty)	1 g	Colour enhancer

Table 2: Solvent System

Sr. No	Solvent	Quantity	Role
1	Ethanol	600 ml	Extraction solvent
2	Distilled water	300 ml	Polar solvent
3	Propylene glycol	100 ml	Humectant and dye fixation

Table 3: Cosmetic Base

Sr. No	Ingredient	Quantity	Role
1	PVP K30	1.5 g	Binding agent
2	Aloe vera gel	50 ml	Conditioner
3	Glycerin	30 ml	Moisturizer
4	Xanthan gum	3 g	Thickening agent
5	Phenoxyethanol	5 ml	Preservative
6	Citric acid	Q.S	pH adjustment

METHOD OF PREPARATION

Step 1: Collection and Drying

- All herbal materials were collected.
- Washed with water to remove impurities.

- Shade dried for 5–7 days.
- Dried materials were powdered.

Step 2: Extraction

- Powder of Phyllanthus reticulatus was soaked in ethanol and water.
- Kept for 24–48 hours.
- Filtered and concentrated to obtain extract.

Step 3: Preparation of Herbal Powder

- All herbal powders were weighed.
- Mixed properly to obtain uniform mixture.

Step 4: Preparation of Base

- Aloe vera gel, glycerin, and propylene glycol were mixed.
- Xanthan gum was added slowly with stirring.
- PVP K30 was added.

Step 5: Preparation of Hair Dye

- Herbal extract was added to base.
- Surma stone powder was added.
- Mixed properly to form uniform paste.
- pH adjusted using citric acid.
- Preservative (Phenoxyethanol) was added.

Step 6: Storage

- Prepared dye was stored in airtight container.

EVALUATION OF HERBAL HAIR DYE



The prepared herbal hair dye was evaluated by the following tests:

1. Organoleptic Evaluation

Purpose: To evaluate physical appearance using sensory organs.

Parameters evaluated:

- Colour
- Odour
- Texture
- Appearance
- Consistency

Procedure:

The prepared dye was visually observed for colour and appearance. The odour was checked by smelling. Texture and consistency were checked by touching and rubbing between fingers.

2. pH Determination

Purpose: To determine scalp compatibility.

Procedure:

- 1 g of dye was dissolved in 10 ml distilled water.
- pH was measured using digital pH meter.

3. Moisture Content

Purpose: To determine stability and storage quality.

Procedure:

- Sample was dried at 105°C.

- Weight loss was recorded.

Result:

Low moisture content indicates good stability.

4. Ash Value

Purpose: To determine purity.

Procedure:

- Sample was burned in crucible.
- Ash obtained was weighed.

5. Phytochemical Evaluation

Purpose: To detect active constituents.

Tests performed:

- Test for alkaloids
- Test for flavonoids
- Test for tannins
- Test for saponins
- Test for phenols

6. Rheological Evaluation

Purpose: To determine flow properties.

Parameters:

- Bulk density
- Tapped density
- Angle of repose

7. Patch Test

Purpose: To check skin irritation.



Procedure:

- Small amount applied on hand.
- Observed for 24 hours.

- Refrigeration

- Elevated temperature

Result:

Formulation was stable.

8. Stability Study

Purpose: To determine formulation stability.

Procedure:

Stored at:

- Room temperature

9. Antimicrobial Test

Purpose: To check antimicrobial activity.

Procedure:

Disc diffusion method was used.

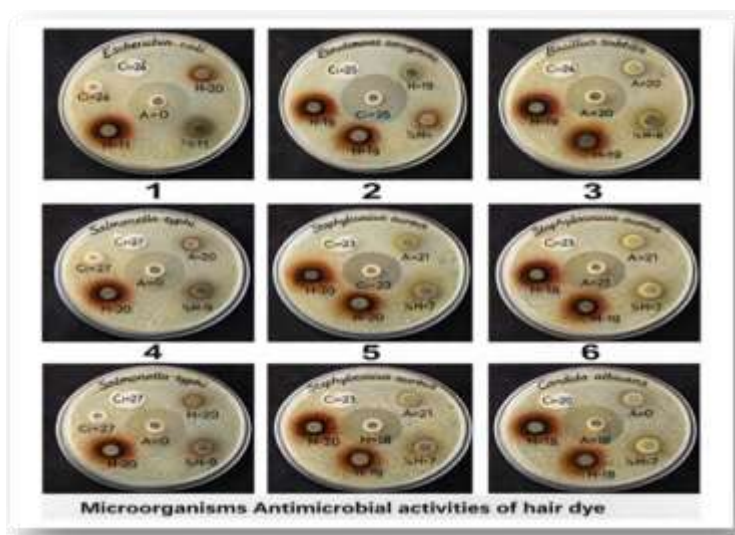


Figure 14: Antimicrobial testing of hair dye

Table 4 : Physico chemical tests of hair dye

Sr. No	Test	Observation	Result
1	Colour	Brownish black	Acceptable
2	Odour	Pleasant	Acceptable
3	Appearance	Smooth and uniform	Good
4	Texture	Smooth	Good
5	Consistency	Semi-solid paste	Suitable
6	pH	6.2	Suitable for scalp
7	Moisture Content	4.5%	Within limit
8	Ash Value	6.8%	Acceptable
9	Bulk Density	0.52 g/ml	Good
10	Tapped Density	0.63 g/ml	Good
11	Angle of Repose	27.5°	Excellent flow
12	Phytochemical Test	Flavonoids, Tannins present	Active compounds present
13	Patch Test	No irritation	Safe
14	Stability Study	No change in colour, odour	Stable
15	Antimicrobial Test	Zone of inhibition observed	Effective

RESULTS AND DISCUSSION

The polyherbal hair dye formulated using *Phyllanthus reticulatus* fruit and other herbal ingredients was evaluated for various parameters. The organoleptic evaluation showed that the formulation had a brownish-black colour, pleasant odour, smooth texture, and uniform appearance, which indicates good acceptability. The pH of the formulation was found to be 6.2, which is within the normal range of scalp pH, indicating that it is safe for application and does not cause irritation.

The moisture content and ash value were within acceptable limits, showing good quality and purity of the formulation. The phytochemical tests confirmed the presence of flavonoids, tannins, and phenolic compounds, which are responsible for colouring and antioxidant activity. The rheological properties such as bulk density, tapped density, and angle of repose indicated good flow properties.

The patch test showed no redness, irritation, or allergic reaction, which confirms the safety of the formulation. The stability study revealed that there was no significant change in colour, odour, or appearance during storage, indicating good stability. The colouring ability test showed that the formulation imparted a uniform brownish-black colour and improved hair texture.

Overall, the results confirmed that the prepared polyherbal hair dye is safe, stable, and effective for colouring hair naturally.

CONCLUSION

The present study successfully focused on the formulation and evaluation of a polyherbal hair dye using *Phyllanthus reticulatus* fruit along with other natural ingredients such as *Lawsonia inermis*, *Hibiscus rosa-sinensis*, *Eclipta prostrata*,

Emblica officinalis, *Vitex negundo*, and Surma stone. These ingredients were selected based on their traditional use, natural colouring ability, and beneficial effects on hair health.

The prepared formulation showed satisfactory organoleptic properties including good colour, pleasant odour, smooth texture, and uniform appearance, indicating good product acceptability. The physico-chemical parameters such as pH, moisture content, and ash value were found to be within acceptable limits, confirming the stability and purity of the formulation. Phytochemical screening confirmed the presence of active constituents like tannins, flavonoids, and phenolic compounds responsible for colouring and antioxidant activity.

The rheological evaluation indicated good flow properties, which ensures ease of handling and application. The patch test confirmed that the formulation is safe and non-irritant to the skin. Stability studies showed no significant changes in physical properties, indicating good stability during storage.

Thus, it can be concluded that the formulated polyherbal hair dye is safe, stable, and effective for natural hair colouring and can be used as a suitable alternative to synthetic hair dyes, which are associated with harmful side effects. The formulation also provides additional benefits such as hair nourishment, strengthening, and protection. Further studies can be carried out to evaluate long-term stability and colouring efficiency on a larger scale.

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