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Development And Evaluation Of A Multifunctional Polyherbal Shampoo Powder

With Natural Hair Coloring Properties

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Abstract: The present study focuses on the development and evaluation of a multifunctional polyherbal shampoo powder with natural hair colouring properties. The formulation was prepared using herbal ingredients such as reetha, shikakai, amla, henna, indigo, hibiscus, neem, and fenugreek, which provide cleansing, conditioning, nourishment, anti-dandruff action, and natural colouring effects. Three formulations (F1, F2, and F3) were prepared with different proportions of henna and indigo to obtain different hair shades. Evaluation parameters included organoleptic properties, powder characteristics, physicochemical tests, foaming ability, wetting time, washability, colour test, and skin irritation test. Results showed good flow properties, suitable pH (5–5.5), good foaming index, easy washability, and no skin irritation. Colour testing showed reddish, brown, and dark brown to blackish shades for F1, F2, and F3 respectively. The study confirms that the polyherbal shampoo powder is a safe, effective, and economical natural alternative to synthetic shampoos and hair dyes.

Keywords: Polyherbal shampoo, Herbal hair dye, Henna, Indigo, Natural coloring, Herbal cosmetics._

I. INTRODUCTION

Hair is an important part of human appearance and plays a significant role in personality and self-confidence. Healthy hair not only improves physical appearance but also reflects good scalp health. In recent years, the use of herbal cosmetics has increased due to their safety, effectiveness, fewer side effects, and eco-friendly nature compared to synthetic products.1 Among herbal cosmetic preparations, herbal shampoo powders have gained considerable attention because they provide cleansing, conditioning, nourishment, and natural hair coloring effects simultaneously.2 A multifunctional polyherbal shampoo powder is a unique formulation that combines several medicinal herbs to achieve multiple benefits such as removal of dirt and dandruff, strengthening of hair roots, prevention of hair fall, promotion of hair growth, and enhancement of natural hair color. 3Traditional herbs such as reetha (Sapindus mukorossi), shikakai (Acacia concinna), amla (Phyllanthus emblica), hibiscus (Hibiscus rosa-sinensis), neem (Azadirachta indica), and henna (Lawsonia inermis) are commonly used due to their proven therapeutic and cosmetic properties.4 Reetha acts as a natural cleansing agent because of its high saponin content, while shikakai provides mild cleansing and conditioning effects. Amla is rich in vitamin C and antioxidants, which help in strengthening hair follicles and preventing premature greying. Hibiscus promotes hair growth and reduces dandruff. Henna serves as a natural coloring agent that imparts a brownish-red shade while also conditioning the hair and scalp.5 Hair graying, dandruff, dryness, and hair fall are common problems caused by pollution, stress, poor nutrition, chemical treatments, and lifestyle changes. Synthetic shampoos and hair dyes may provide quick results, but their prolonged use can lead to scalp irritation, dryness, allergic reactions, and hair damage due to harsh chemicals such as sulfates, parabens, and ammonia-based dyes.6 Therefore, the development of a herbal shampoo powder with

natural coloring properties offers a safer and more sustainable alternative.The present study focuses on the development and evaluation of a multifunctional polyherbal shampoo powder that not only cleanses and nourishes the hair but also provides natural coloring effects. Such a formulation can serve as an economical, effective, and consumer-friendly herbal cosmetic product with improved therapeutic value.

II. Structure and Composition of Hair

1.1 Hair Scalp Anatomy

Hair follicles, which are found at the junction of the deep layers of the dermis and the subcutaneous tissue, are responsible for the production of hair on the human body. These follicles, also known as hair bulbs, produce the hair shaft. Small blood vessels pass through the center of the hair follicle and supply blood to the hair shaft, providing essential nutrients such as vitamins, amino acids, and mineral salts that are necessary for maintaining healthy hair growth.7 Glands also surround the hair shaft, among which the sebaceous gland is the most important. This gland produces sebum, which naturally lubricates the hair and helps maintain scalp moisture. Sweat glands present in the scalp help in removing sweat through surface pores.

Approximately 95% of the hair shaft is composed of keratin, a fibrous helical protein produced by keratinocytes. Keratin is insoluble in water and provides protection, strength, and impermeability to the hair.8 Hair also contains eighteen other amino acids, including proline, leucine, threonine, and arginine. Among these, cysteine is particularly important because it is a sulfur-containing amino acid that forms disulfide bonds between molecules, giving the hair strength, stiffness, and resilience. Hair structure also varies among different ethnic groups. African hair generally has a larger diameter, Caucasian hair is usually finer and thinner with a somewhat oval shape, while Mongolian hair has a cross-section similar to Caucasian hair and may range from flat to wavy.9

1.2 Composition and Morphology of Hair Fiber

The hair shaft is composed of dead skin cells that have undergone keratinization. These cells originate from hair follicles, which are invaginations extending into the dermis or subcutaneous tissue. In addition to keratin, hair contains small amounts of water-soluble substances such as uric acid, pentose, phenols, glycogen, glutamic acid, leucine, and valine. The hair shaft mainly consists of four major structural components: the medulla, cuticle, cortex, and the cell membrane complex (CMC).10

Medulla

The medulla is the innermost layer of the hair shaft and is composed of a soft, greasy, and amorphous substance. It is usually discontinuous or may even be absent in some hair types, and therefore it has little effect on the overall structure of hair. The medulla may act as a pigment reservoir and may be empty or contain fungal keratin. It can also contribute to the brightness and shine of the hair. Compared to other parts of the hair shaft, the medulla contains a higher concentration of lipids.11

Cuticle

The cuticle is the outermost protective layer of the hair shaft and is highly keratinized. It is made up of scale-shaped cells arranged in overlapping layers, with each cell measuring approximately 60 micrometers in length and 6 micrometers in width. The cuticle protects the inner structures of the hair and provides resistance against chemical damage. It also regulates the amount of water present in the hair structure, helping to maintain the physical properties and smoothness of the hair.12

The cuticle usually contains six to ten layers of overlapping cells arranged in the longitudinal direction of the fiber. Damage to the cuticle can occur due to environmental exposure, mechanical friction caused by brushing and combing, and excessive use of shampoos or inappropriate cosmetic products. Such damage can lead to dryness, roughness, and hair breakage.13

Cell Membrane Complex (CMC)

The Cell Membrane Complex (CMC) is an important structural component of hair that consists of cell membranes and an adhesive substance that binds the cuticle and cortical cells together. It acts like a “glue” that maintains the integrity of the hair fiber. The chemical composition of CMC includes proteins, polysaccharides, and ceramides. It is also responsible for maintaining the natural moisture of the hair, which contributes to hair shine, softness, and hydration.14

Cortex

The cortex is the main structural component of the hair shaft and forms the largest portion of the hair fiber. It is composed of long keratin chains that provide strength, elasticity, flexibility, and resilience to the hair. The cortical cells are held together by an intercellular cement rich in proteins and lipids.

Each cortical cell contains bundles known as macrofibrils, which run along the length of the hair shaft. These macrofibrils are made up of smaller units called microfibrils, which further contain protofibrils. The cortex is mainly composed of cylindrical cells approximately 100 μm long and 1 to 6 μm thick. It

forms the matrix where keratin and other proteins are present and contributes significantly to the mechanical strength and natural color of the hair.15

IV. Types of hair dyes:

1.Temporary

• Hair can be temporarily colored with these colors.
• It's simple to rinse off water after shampooing Puffer spray and finely ground metals are used to temporarily tint hair.
• For temporary color, setting lotion and powder are utilized.
• To temporarily color your hair, use a crystal violet and leuco derivative of a basic dye.16

2.semi-permanent

• Shampoo is the most often used foundation for semipermanent hair dye.
• We use a solvent to enhance colorant performance. Because of their cationic qualities, they have a natural affinity for hair.
• Nitroaminophenes, nitrophenylene diamines, or both aminoanthraquinoes are present.17

3.permanent

• The slow oxidation process involves a coupling reaction between the intermediates and modifiers.
• Permanent hair dye works incredibly well on white and mixed-race hair. Hair damage could result from it.18

V. How natural hair dyeing works:

• Lawson is a naturally occurring red coloring ingredient found in henna.19 When henna paste is applied to hair, it coats the hair shaft. Lawson then progressively moves from the henna to the hair shaft through the cuticle's gaps, where it mixes with keratin to fortify the cuticle.20 The end product is hair with a natural color.21 The color of the hair deepens and settles with regular application.22
• Both the hair's strength and its capacity to hold onto moisture will improve.23,24Additionally, dandruff and hair loss are decreased, and the scalp's condition improves.25 The henna coating on the surface shields the hair from pollution and UV rays, giving it a healthy, glossy appearance.
• Herbriller uses henna (and its coloring component Lawson) as one of the 100% natural chemicals to conceal white and gray hair. Herbriller offers a variety of colors that use other natural dyes, such indigo, to create various shades of brown for hair in case consumers want something different from Lawson orange.26
• Indigo is commonly used as a natural hair dye to impart dark shades to hair. Unlike henna, which provides a reddish-orange color, indigo contains indican, which is hydrolyzed during preparation to produce indigotin, the blue dye molecule. When applied to hair, indigotin binds with hair proteins, especially after pre-treatment with henna, creating a stable dark brown or black color. The dyeing effect is gradual and natural, and it is less damaging compared to synthetic chemical dyes.27

VI Advantages of Herbal Hair Dye over Synthetic Hair Dye:

Herbal hair dye offers several advantages over synthetic hair dye because it contains the natural benefits of medicinal plants and herbs. The prepared herbal hair dye not only works as a coloring agent but also acts as a hair growth promoter, conditioner, and anti-dandruff treatment due to the synergistic effect of its herbal ingredients.28 Because of this multifunctional nature, herbal formulations are considered safer and more beneficial for long-term hair care compared to synthetic chemical dyes.

Henna (Lawsonia inermis) is widely used throughout the world as a basic natural hair coloring agent because of its excellent dyeing property.29 It imparts a natural reddish-brown color to the hair while also nourishing the scalp and helping to remove excess oil.30 Henna strengthens hair roots, improves hair texture, and provides cooling effects to the scalp.

Reetha (Sapindus mukorossi) is known for its natural cleansing and conditioning properties. It helps in revitalizing dry, damaged, and lifeless hair by gently removing dirt and excess oil without disturbing the natural moisture balance of the scalp.31 Its rich saponin content acts as a natural surfactant, making it an excellent herbal cleansing agent.

Shikakai (Acacia concinna) contains important bioactive compounds such as saponins, flavonoids, and antioxidants that support hair and scalp health. These compounds help remove excess sebum, cleanse

clogged scalp pores, and provide antimicrobial activity against scalp infections. 32As a result, shikakai promotes healthy hair growth and improves scalp hygiene. Its benefits are mainly due to its natural surfactant and antioxidant properties.

Hibiscus (Hibiscus rosa-sinensis) is highly effective in reducing dandruff, controlling hair fall, and delaying premature greying of hair.33 Regular use of hibiscus flower extract helps maintain healthy and naturally dark hair. It also contains essential fatty acids that strengthen hair follicles, improve shine, and increase hair vitality.34

Amla (Phyllanthus emblica) is rich in vitamin C and antioxidants, which help prevent premature greying and strengthen hair follicles.35 It acts as an excellent natural conditioner and also helps in reducing dandruff, improving scalp health, and enhancing overall hair texture.

The organoleptic evaluation of herbal hair dye powder generally shows that the formulation is smooth, aromatic, and pleasant in appearance. Physicochemical studies reveal low moisture content, which helps improve stability and prevents microbial growth. The pH is usually found to be neutral, making the formulation suitable for different scalp types. The ash value remains within acceptable limits, indicating the presence of essential inorganic components in suitable concentrations. These findings confirm the presence of valuable phytoconstituents that provide nourishment to both hair and scalp.36

The irritation test usually shows negative results for redness, swelling, or irritation because the herbs are naturally compatible with hair proteins and do not contain harsh synthetic additives.37 Stability studies conducted at different temperatures show that the formulation remains stable in terms of color, odor, texture, appearance, and pH over time.38Since the preparation is made from dried natural plant materials and contains no artificial preservatives, colors, fragrances, or harmful chemicals such as ammonia, the possibility of product deterioration is very low.39

Unlike synthetic hair dyes, herbal hair dye does not cause harmful side effects such as scalp irritation, dryness, allergic reactions, or hair damage associated with ammonia-based chemical dyes.40 Regular use of herbal hair dye results in soft, silky, voluminous, and naturally colored hair with excellent long-term benefits.41The natural ingredients are non-toxic, non-habit-forming, and environmentally friendly, making herbal hair dye a safer and more sustainable option for complete hair care. Additionally, the absence of chemicals and preservatives increases product stability and extends shelf life.

VII. Causes of Hair Graying

Hair graying is a natural part of the aging process; however, premature graying can occur due to several internal and external factors. The reduction in melanin production by melanocytes present in the hair follicles is the primary reason for the appearance of gray or white hair. Various factors such as vitamin deficiency, genetics, oxidative stress, medical conditions, smoking, and the use of chemical hair products contribute significantly to premature hair graying.

Vitamin Deficiency

Deficiency of essential vitamins such as biotin, vitamin D, vitamin E, vitamin B6, and vitamin B12 can contribute to premature graying of hair. These vitamins play an important role in maintaining healthy pigmentation and proper functioning of melanocytes. A study published in Development in 2015 reported a strong relationship between deficiencies of vitamin B12, vitamin D3, copper, and early hair graying. Nutritional deficiencies may disturb melanin synthesis, and proper vitamin supplementation may help restore natural hair color.42

Genetics

Genetics is considered one of the most important causes of premature hair graying. The age at which a person begins to develop gray hair is often inherited from family members. According to a 2013 study published in the Indian Journal of Dermatology, Venereology and Leprology, premature graying may begin as early as 20 years of age in White individuals and around 25 years of age in Asian populations. Race and ethnicity also influence the timing and pattern of hair graying.43

Oxidative Stress

Oxidative stress plays a major role in accelerating the graying process. It occurs when the body's antioxidant defense system becomes insufficient to neutralize the harmful effects of free radicals. Free radicals are unstable molecules that cause cellular damage and contribute to aging and various diseases. Excess oxidative stress can damage melanocytes and reduce melanin production, leading to premature graying. Conditions such as vitiligo, which involve loss of pigmentation, are also associated with oxidative damage and white hair formation.44

Particular Medical Conditions

Certain medical conditions, especially autoimmune disorders, can increase the risk of early hair graying. Thyroid disorders have been found to be associated with changes in hair pigmentation and structure.45 A study conducted in 2008 reported a strong relationship between thyroid dysfunction and hair abnormalities. Autoimmune diseases such as alopecia areata can also result in white hair.46 In alopecia areata, hair loss occurs from the scalp, face, or other body parts, and the regrown hair often appears white due to reduced pigment production.

Smoking

Smoking is another major factor associated with premature hair graying. Harmful chemicals present in cigarette smoke increase oxidative stress and damage melanocytes, leading to early pigment loss. A 2013 study published in the International Journal of Trichology reported that smokers were found to be 2.5 times more likely to develop premature graying compared to non-smokers.47 Another study published in the Journal of the American Academy of Dermatology in 2015 also confirmed a strong association between smoking at a young age and early onset of gray hair.48

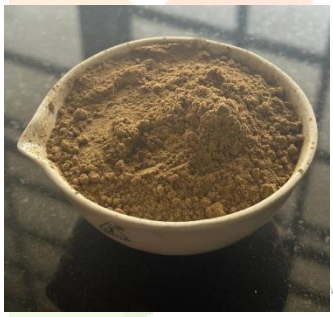
Chemical Hair Colors and Hair Products

Frequent use of chemical hair dyes, harsh shampoos, and other cosmetic hair products may also accelerate the development of gray hair. Many synthetic products contain harmful chemicals such as ammonia, hydrogen peroxide, sulfates, and parabens, which can damage the hair shaft and affect melanocyte function. Continuous exposure to such chemicals weakens hair health and may contribute to premature graying over time.49

VIII. RESEARCH METHODOLOGY

Ingredients:

1. Reetha (Soapnut)



Biological Source: Dried pericarps (fruits) of ***Sapindus mukorossi***
Family: Sapindaceae
Synonyms: Soapnut, Aritha, Ritha
Morphology:

- Fruits are round, smooth, and yellowish-brown
- Pericarp is thick, leathery, and translucent
- Seeds are black, hard, and glossy
- Odour slight; taste bitter and acrid

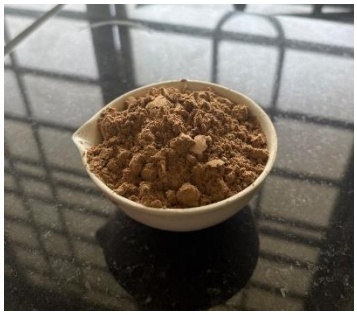
Chemical Constituents:

- Contains saponins (10–11%) as the major active principle
- Also contains sugars (glucose, fructose) and fatty acids
- Saponins produce stable foam in water

Uses:

- Used as a natural surfactant and cleansing agent
- Widely used as herbal shampoo for hair growth and dandruff control
- Acts as a mild expectorant
- Used in detergents and soaps

2.Shikakai

Biological Source: Dried pods of ***Acacia concinna***
Family: Fabaceae
Synonyms: Soap pod, Shikakai
Morphology

- Small climbing shrub commonly found in tropical regions of India
- Thorny branches with bipinnate leaves
- Leaves have small leaflets
- Flowers are yellowish-pink and arranged in clusters
- Fruits are long, flat, brown-colored pods containing several seeds
- Dried pods are mainly used for medicinal and cosmetic purposes

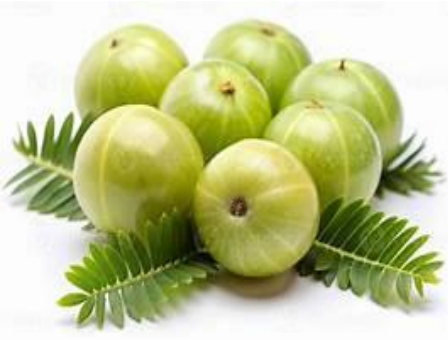
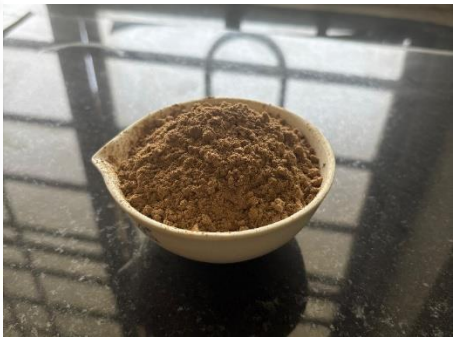
Chemical Constituents

- Contains saponins (major active constituents)
- Also contains flavonoids, alkaloids, tannins, and glycosides
- Rich in natural antioxidants
- Saponins provide natural cleansing and foaming properties
- These compounds contribute to antimicrobial, cleansing, and conditioning effects

Uses

- Used as a natural hair cleanser and conditioner
- Helps remove dirt, excess oil, and dandruff from the scalp
- Maintains natural pH balance of the scalp
- Promotes healthy hair growth
- Reduces hair fall and strengthens hair roots
- Helps prevent scalp infections due to antimicrobial properties
- Improves hair softness, shine, and manageability
- Commonly used in herbal shampoo powders and hair care formulations

3. Amla

Biological Source: Fresh and dried fruits of ***Phyllanthus emblica***
Family: Phyllanthaceae
Synonyms: Amalaki, Indian Gooseberry
Morphology:

- Fruits are round, smooth, and greenish-yellow
- Surface shows 6 vertical furrows
- Taste is sour and astringent
- Seeds are hard and triangular

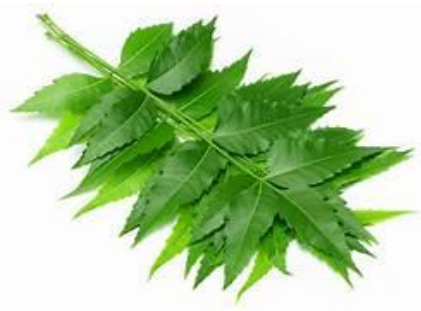
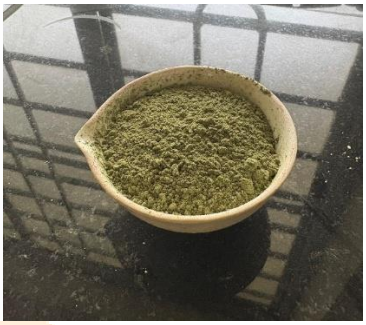
Chemical Constituents:

- Rich in Vitamin C (heat stable due to tannins)
- Contains tannins (emblicanin A & B)
- Also contains gallic acid, ellagic acid, and polyphenols
- Strong antioxidant nature

Uses:

- Used as a powerful antioxidant and immunity booster
- Promotes hair growth and prevents premature greying
- Used in Triphala formulation

4. Neem

Biological Source: Leaves, bark, and seeds of ***Azadirachta indica***
Family: Meliaceae
Synonyms: Margosa tree
Morphology:

- Leaves are compound, pinnate, and serrated
- Bark is rough and brown
- Flowers are small, white, and fragrant
- Taste is characteristically bitter

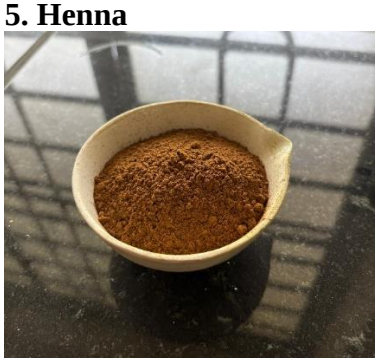
Chemical Constituents:

- Contains azadirachtin (major insecticidal compound)
- Also contains nimbin, nimbidin, gedunin, and quercetin
- Shows antimicrobial and anti-inflammatory properties

Uses:

- Used as antibacterial and antifungal agent
- Treats skin diseases like acne, eczema, infections
- Used as a natural pesticide and insect repellent
- Used in oral hygiene (tooth sticks)
- Acts as a blood purifier

5. Henna

Biological Source: Dried leaves of ***Lawsonia inermis***
Family: Lythraceae
Synonyms: Mehndi
Morphology:

- Leaves are opposite, lanceolate, and entire
- Flowers are small, fragrant, white or pink

- Powder is green in color with characteristic smell

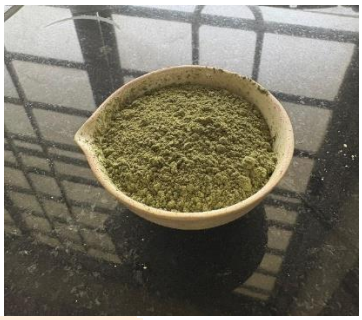
Chemical Constituents:

- Contains lawsone (main coloring principle)
- Also contains tannins and flavonoids
- Lawsone binds with keratin

Uses:

- Used as a natural dye for hair, skin, and nails
- Acts as a cooling agent
- Shows antifungal and antimicrobial activity
- Used as hair conditioner

6. Indigo

Biological Source: Leaves of ***Indigofera tinctoria***
Family: Fabaceae
Synonyms: True Indigo
Morphology:

- Small shrub with branched stem
- Leaves are pinnate and green
- Flowers are pink or purple
- Leaves yield dye on processing

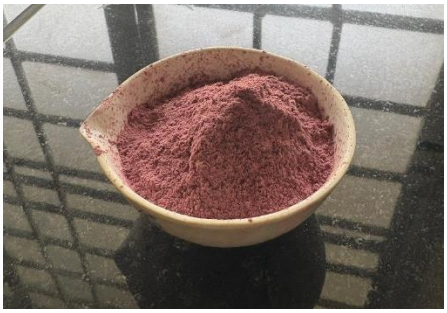
Chemical Constituents:

- Contains indican (glycoside precursor)
- On hydrolysis forms indigotin (blue dye)
- Also contains indigoferin

Uses:

- Used as a natural blue dye in textile industry
- Used in hair coloring (with henna → black color)
- Traditional dyeing agent

7. Hibiscus

Biological Source: Flowers of ***Hibiscus rosa-sinensis***
Family: Malvaceae
Synonyms: China Rose, Shoe flower
Morphology:

- Large, flowers (usually red)
- Leaves are ovate with serrated margins
- Contains mucilage giving slimy texture

Chemical Constituents:

- Contains anthocyanins (color pigments)
- Also contains flavonoids, mucilage, and organic acids
- Provides antioxidant and soothing effects

Uses:

- Used as a hair growth promoter and natural conditioner
- Used in herbal teas for controlling blood pressure
- Acts as a cooling and soothing agent
- Used in cosmetic preparations

8. Fenugreek

Biological Source: Dried ripe seeds of ***Trigonella foenum-graecum***
Family: Fabaceae
Synonyms:
Fenugreek, Methi, Greek hay, Bird's foot

Morphology

- Seeds are small, yellowish-brown, hard, and irregularly rhomboidal
- One side shows a deep groove (furrow)
- Odour is strong and characteristic
- Taste is bitter and mucilaginous
- Surface is smooth and slightly glossy

Chemical Constituents

- Contains alkaloids (Trigonelline, Choline)
- Steroidal saponins (Diosgenin – very important)
- Proteins and amino acids
- Mucilage (galactomannan)
- Fixed oils and flavonoids

Uses

- Acts as a carminative and digestive stimulant
- Used in diabetes management (reduces blood sugar levels)
- Promotes lactation (galactagogue)
- Used as a nutritive and tonic
- Helps in hair growth and dandruff control
- Used in spices and food preparations

Formulation table :50

F1-Reddidh tone(heena rich)

Sr.no	Ingredients	Role	Quantity taken
1.	Reetha	Cleansing	10g
2.	Shikaki	conditioner	7.5g
3.	Amla	Nourishment	7.5g
4.	Heena	colouring	12.5g
5.	Indigo	Mild darkening	2.5g
6.	Hibiscus	Hair growth	5g
7.	Neem	Anti dandruff	2.5g
8.	Feugreek	conditioning	2.5g

F2-Brown tone(balanced)

Sr.no	Ingredients	Role	Quantity taken
1.	Reetha	Cleansing	10g
2.	Shikaki	conditioner	7.5g
3.	Amla	Nourishment	7.5g
4.	Heena	colouring	10g
5.	Indigo	Dark shade	5g
6.	Hibiscus	Hair growth	5g
7.	Neem	Anti dandruff	2.5g
8.	Feugreek	moisturizer	2.5g

F3-Dark Tone (Indigo Rich)

Sr.no	Ingredients	Role	Quantity taken
1.	Reetha	Cleansing	10g
2.	Shikaki	conditioner	7.5g
3.	Amla	Nourishment	7.5g
4.	Heena	colouring	7.5g
5.	Indigo	Dark shade	10g
6.	Hibiscus	Hair growth	5g
7.	Neem	Anti dandruff	2.5g
8.	Feugreek	conditioning	2.5g

Method of Preparation:51,52,53,54,55

1. Verification of Raw Materials

Reetha, Shikakai, Amla, Henna, Indigo, and other natural ingredients were procured from reliable and trusted suppliers. The raw materials were authenticated using morphological characteristics, organoleptic properties, and standard pharmacognostic procedures as described in pharmacopoeias and published literature. This step ensured the purity, identity, and quality of the herbal drugs before formulation.

2. Pre-processing of Raw Drugs

2.1 Cleaning

The raw materials were thoroughly washed using distilled water to remove dust, soil particles, and foreign organic matter. Proper cleaning was necessary to prevent contamination and ensure the safety and quality of the final formulation.

2.2 Drying

The cleaned materials were shade-dried for five to seven days at a temperature of 25–30°C. Direct sunlight was avoided to prevent degradation of active phytoconstituents and natural coloring compounds such as lawsone present in henna and indigotin present in indigo. Shade drying helped preserve the medicinal and coloring properties of the herbs.

2.3 Size Reduction

After complete drying, the raw materials were crushed separately using a mechanical grinder. Each ingredient was converted into a fine powder to improve mixing, uniformity, and ease of application.

2.4 Sieving

The powdered materials were passed through sieve number 80 to obtain uniform particle size and a smooth texture. Coarse particles remaining on the sieve were reground and sieved again to maintain consistency in the formulation.

3. Formulation of Shampoo Powder

3.1 Weighing

Each ingredient was accurately weighed according to the formulation table using a digital analytical balance. Precise weighing ensured proper formulation and maintained consistency in product quality.

3.2 Geometric Mixing Method

The ingredients were mixed using the geometric dilution method to ensure uniform distribution of all components.

Initially, the ingredient present in the smallest quantity, such as indigo powder, was taken first. An equal quantity of another ingredient, such as neem powder, was added and mixed thoroughly using a mortar

and pestle. The process was continued by gradually adding larger quantities of ingredients such as henna, amla, shikakai, and finally reetha, which was present in the largest amount.
This method helped achieve uniform mixing and prevented separation of fine and coarse particles.

3.3 Blending
The prepared mixture was further blended using a mechanical mixer or blender for 10–15 minutes. This step ensured homogeneity, consistency, and proper distribution of all herbal ingredients throughout the formulation.
3.4 Final Sieving
The blended powder was passed once again through sieve number 80 to break lumps, improve smoothness, and enhance spreadability during application on hair and scalp.
3.5 Final Powder Quality Check
The final prepared formulation was evaluated visually for uniform color, lump-free nature, free-flowing property, and overall appearance. This ensured the quality and acceptability of the finished herbal shampoo powder.
4. Packaging
The finished shampoo powder was packed in laminated pouches or airtight HDPE containers to protect it from moisture and environmental contamination. Proper packaging helped maintain product stability and extended shelf life. For research purposes and stability studies, desiccants were used to prevent moisture absorption. The product was stored in a cool and dry place.
5. Labeling
The final container was properly labeled with important information including formulation name, batch number, date of preparation, storage conditions, and instructions for use. Proper labeling ensured identification, traceability, and correct usage of the formulation.

IX. Evaluation Parameter

1) Organoleptic Evaluation
Organoleptic evaluation was performed to examine the physical properties of the powder shampoo, including colour, smell, and texture. The colour was checked visually under normal light conditions. Texture was determined by touching the powder to evaluate its smoothness and fineness. For odour assessment, a panel of individuals with good smell sensitivity was selected, and random samples were tested to determine the fragrance and overall acceptability of the formulation.
2) General Powder Characteristics
The general powder characteristics were studied to evaluate properties that influence the external quality of the formulation, such as appearance, flow behavior, handling, and packaging. The parameters assessed included powder form, particle size, angle of repose, bulk density, tapped density, Carr's index, and Hausner's ratio. Samples were taken from the upper, middle, and lower portions of the powder to ensure uniform distribution and consistency throughout the preparation.
Angle of Repose
The angle of repose was determined using a glass funnel fixed with a clamp on a ring stand above a glass plate. The glass plate was placed on a micro lab jack for height adjustment. About 10 g of powder was placed into the funnel while the funnel opening was closed using the thumb. After removing the thumb, the powder was allowed to flow freely onto the glass plate. The lab jack was adjusted to maintain a distance of about 2 cm between the end of the funnel stem and the top of the powder heap formed. Once all the powder had passed through the funnel, the angle formed between the surface of the powder heap and the horizontal plane was measured using a protractor. The height (h) and radius (r) of the powder pile were measured with a ruler.
$\Theta = \tan^{-1}(h/r)$
Where:
h = Height of the powder heap formed
r = Radius of the base of the powder heap
Bulk Density
Bulk density is defined as the ratio of the mass of an untapped powder sample to its total volume, including the space between the particles (interparticulate void volume). It depends on both the actual density of the powder particles and their arrangement within the powder bed. Bulk density is expressed in g/cm³. For its determination, a 100 mL graduated cylinder was taken and a measured quantity of

herbal shampoo powder was added to it. The cylinder was then placed in a bulk density apparatus, and the bulk density was calculated. This parameter is important for evaluating packaging requirements and maintaining uniformity in the bulk product.

Bulk Density = Mass of Powder / Bulk Volume of Powder

Tapped Density

Tapped density refers to the increased bulk density obtained after mechanically tapping a container containing the powder sample. After noting the initial volume or mass of the powder, the measuring cylinder was tapped mechanically for about 1 minute. The readings were recorded repeatedly until no significant change in volume or mass was observed. Tapped density is also expressed in g/cm³ and helps in evaluating the packing ability of the powder.

Tapped Density = Mass Taken / Tapped Volume

Compressibility Index (Carr's Index)

Carr's Index is used to determine the compressibility and flow properties of a powder. It indicates how easily a powder can be compressed by comparing the difference between tapped density and bulk density. A lower value shows better flow properties, while a higher value indicates poor flow and higher compressibility.

Carr's Index = (Tapped Density − Bulk Density) / Tapped Density × 100

Hausner's Ratio

Hausner's Ratio is an indirect method used to measure the flowability and compressibility of powder materials. It shows the ability of the powder to decrease in volume under mechanical force and also indicates the level of interaction between particles. A lower Hausner's ratio suggests good flow properties, while a higher value indicates poor flow behavior.

Hausner's Ratio = Tapped Density / Bulk Density

3) Physicochemical Evaluations

Ash Value

Ash value is used to determine the purity, quality, and identity of the polyherbal shampoo powder with dye. It helps in detecting the presence of inorganic impurities such as dirt, sand, and other foreign matter.

Determination of Total Ash

A clean, dry porcelain dish or silica crucible was first weighed and ignited. About 2 g of the herbal shampoo powder formulation was accurately weighed and placed into the dish. The dish was supported on a pipe-clay triangle fixed on a ring stand and heated gently over a burner flame placed about 7 cm below the dish. Initially, heating was done slowly until vapours stopped evolving, after which stronger heating was applied until all the carbon content was completely burnt off. The dish was then cooled in a desiccator and weighed. The percentage of total ash was calculated with reference to the air-dried powder sample.

Total Ash Value = $100(z - x) / y$ %

Where:

$(z - x)$ = Weight of ash obtained

y = Weight of drug taken

Determination of Acid Insoluble Ash

The total ash obtained was boiled for 5 minutes with 25 mL of dilute hydrochloric acid. The insoluble matter was filtered through a Gooch crucible or ashless filter paper, washed with hot water, and then ignited to constant weight. The percentage of acid-insoluble ash was calculated for each sample.

Acid Insoluble Ash Value = $a / y \times 100$

Where:

a = Weight of acid-insoluble ash

y = Weight of drug taken

Determination of Water-Soluble Ash

Water-soluble ash was determined using the same procedure as acid-insoluble ash, but 25 mL of water was used instead of dilute hydrochloric acid. The remaining insoluble matter was collected, dried, ignited, and weighed. The percentage of water-soluble ash was then calculated.

Water Soluble Ash Value = $a / y \times 100$

Where:

a = Weight of water-insoluble ash

y = Weight of drug taken

Moisture Content Determination

For the determination of moisture content, 10 g of polyherbal shampoo powder with dye was accurately weighed and placed in a previously weighed evaporating dish. The dish was then kept in a hot air oven maintained at 105°C. The sample was dried, and the loss in weight was recorded at intervals of 15 minutes until a constant weight was obtained. The decrease in weight indicated the amount of moisture present in the sample.

Total Moisture Content = a / y × 100

Where:

a = Weight of moisture lost

y = Weight of drug taken

pH Determination Using pH Paper

For the determination of pH, 1 g of each polyherbal shampoo powder with dye formulation was accurately weighed and dissolved in 10 mL of distilled water. The mixture was stirred well to obtain a uniform solution. A strip of pH paper was then dipped into the prepared solution for a few seconds and removed. The colour change on the pH paper was compared with the standard colour chart provided with the pH paper to determine the pH value of the formulation. This method helps in checking whether the shampoo powder is suitable for scalp and hair application.

Foaming Index

The foaming index is used to evaluate the foam-producing capacity of the polyherbal shampoo powder formulation. For this test, 1 g of the powder was mixed with 100 mL of distilled water and boiled for about 30 minutes. After cooling, the solution was filtered and the volume was adjusted to 100 mL with distilled water. This prepared decoction was used for further testing.

Different quantities of the decoction (1 mL, 2 mL, 3 mL, and so on) were transferred into separate test tubes, and the volume in each tube was made up to 10 mL with distilled water. Each test tube was shaken vigorously for 15 seconds and allowed to stand for 15 minutes. The height of foam formed in each test tube was observed.

The foaming index was calculated based on the tube in which 1 cm of foam was produced.

Foaming Index = 1000 / a

Where:

a = Volume in mL of decoction required to produce 1 cm of foam

Dirt Dispersion Test

For the dirt dispersion test, two drops of 1% polyherbal shampoo powder with dye formulation were added into a large test tube containing 10 mL of distilled water. One drop of Indian ink was then added to the test tube. The tube was closed with a stopper and shaken well. The amount of ink present in the foam was observed and recorded as none, moderate, or heavy. Less ink in the foam indicates better cleansing action of the shampoo formulation.

Wetting Time

For the wetting time test, a piece of canvas paper was cut into discs of 1-inch diameter. These discs were carefully placed on the surface of a 1% solution of polyherbal shampoo powder with dye. The time taken for each disc to start sinking was measured using a stopwatch and recorded as the wetting time. A shorter wetting time indicates better wetting ability of the formulation.

Washability

A small quantity of the shampoo powder formulation was applied to the skin and then washed with water. The ease with which the formulation was removed from the skin was observed. If it was removed easily without leaving residue, it was considered to have good washability.

Colour Test

The prepared polyherbal shampoo powder with dye was evaluated for its colouring effect using blonde human hair. A small amount of the formulation was applied evenly to the blonde hair sample and left for a specific period of time, followed by washing with water and drying. The hair was then observed visually to check the presence or absence of colour deposition. The intensity and uniformity of the colour developed on the hair were also noted to assess the colouring efficiency of the formulation**.**

Skin Irritation Test

Prepared Polyherbal shampoo powder with dye was tested for skin irritation test. The test was performed on skin of hand of volunteers and check whether its irritation on skin was absent or present

X. Results:

1) Organoleptic Evaluation:

Sr.no	Parameter	Observation
1.	Colour	Yellowish Beown
2.	Odor	Characteristics
3.	Texture	Smooth

2) General Characteristics:

Sr.no	Parameter	Observations		
		F1	F2	F3
1.	Angle of Repose	38.30	38.32	38.31
2.	Bulk Density	0.35g/ml	0.35g/ml	0.35g/ml
3.	Tapped Density	0.59g/ml	0.56g/ml	0.59g/ml
4.	Carr's Index	40.95	37.99	40
5.	Hausner ratio	1.69	1.61	1.66

3) Physicochemical Evaluations:

Ash Value

Ash value was determined to evaluate the quality and purity of the polyherbal shampoo powder with dye. The total ash value was found to be **3% w/w**, indicating good quality and low inorganic impurities in the formulation.

$$\text{Total Ash Value} = \frac{100(z - x)}{y}$$

Where:
(z − x) = Weight of ash obtained
y = Weight of drug taken
Calculation:
Total Ash Value = 100 × 0.06 / 2 = **3% w/w**
This result indicates acceptable purity and good quality of the prepared formulation**Acid Insoluble Ash**
Acid insoluble ash value was determined to measure the inorganic impurities and purity of the polyherbal shampoo powder with dye. It was found to be 1% w/w, indicating low inorganic content and good purity of the formulation.

$$\text{Acid Insoluble Ash Value} = \frac{a}{y} \times 100$$

Where:
a = Weight of acid insoluble ash
y = Weight of drug taken
Calculation:
Acid Insoluble Ash Value = 0.02 / 2 × 100 = **1% w/w**
This result shows acceptable purity and minimal inorganic contamination in the prepared formulation.

Water Soluble Ash

Water soluble ash value was determined to measure the portion of total ash that dissolves in water, indicating the presence of water-soluble minerals and salts in the polyherbal shampoo powder with dye. It was found to be 3.5% w/w, showing the presence of acceptable amounts of soluble minerals in the formulation.

$$\text{Water Soluble Ash Value} = \frac{a}{y} \times 100$$

Where:
a = Weight of water-soluble ash
y = Weight of drug taken
Calculation:
Water Soluble Ash Value = 0.07 / 2 × 100 = **3.5% w/w**
The result indicate good quality and acceptable mineral content in the formulating

Moisture Content

Moisture content was determined to ensure that the polyherbal shampoo powder with dye remains free-flowing, prevents clumping, and maintains stability during storage. It was found to be **4.66%**, indicating good stability and suitable moisture level in the formulation.

$$\text{Total Moisture Content} = \frac{a}{y} \times 100$$

Where:

a = Weight of moisture lost

y = Weight of drug taken

For F1 formulation Moisture content =**3.8%**

For F2 formulation moisture content=**4.2%**

For F3 formulation Moisture Content =**3.3%**

pH:

pH of polyherbal shampoo powder with dye was found to be in between **5-5.5.**

Foaming Index

foaming index indicates the capability of a substance to form a foam, trapping the air or gas in a liquid or solid matrix. This is important for accessing surfactant, proteins and other foaming agents and it was found to be 250%.

Foaming Index= 1000/a

Were,

a= volume in ml of the decoction in the test tube showing one cm foam height

Foaming index=1000/a =1000/4 =**250%**

Foaming index 250%% it indicates that good foaming index of polyherbal shampoo powder with dye.

Dirt Dispersion

Dirt dispersion is an important criterion for evaluation the cleansing action of shampoos and ink foam was found to be moderate.

Wetting Time

Wetting time is a crucial test for polyherbal shampoo powder with dye to evaluate how quickly the powder can become wet and ready for use and it was found to be **6 seconds**.

Washability

Washability is important test to check the washing action of shampoo which should remove the grease and dirt particles from the scalp and hair fibres. This herbal shampoo shows a good washability with easily removal of the grease and dirt particles.

Colour Test

10 g of polyherbal shampoo powder with dye was applied to separate samples of human blonde hair and left for 30 minutes. After that, the hair samples were washed with water and allowed to dry. It was observed that formulation F1 showed a reddish tone, formulation F2 showed a brown tone, and formulation F3 showed a dark brown to blackish tone.

Skin Irritation Test

Polyherbal shampoo powder with dye was tested for skin irritation test. The test was performed on skin of hand of volunteers and its irritation on skin was absent.

Conclusion

The developed polyherbal shampoo powder with natural hair colouring properties showed satisfactory cleansing, conditioning, and colouring performance. The formulation possessed acceptable organoleptic properties, good foaming ability, proper wetting time, suitable pH, and good washability. It also demonstrated excellent safety by showing no skin irritation. Different formulations successfully produced different hair shades ranging from reddish to dark brown-black depending on the henna and indigo content. The study concludes that the prepared herbal shampoo powder is an effective, safe, stable, and economical alternative to synthetic shampoos and hair dyes, offering both cosmetic and therapeutic benefits for hair care.

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