

Formulation, Evaluation, and Phytochemical Screening of a Bio-Active Polyherbal Face Pack

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Abstract

Skin care formulations containing synthetic chemicals often lead to side effects like irritation, redness, and chronic dryness. Herbal cosmetics offer a safer, synergistic alternative. Objective: The present study focuses on the formulation, evaluation, and phytochemical screening of a bioactive polyherbal face pack containing Neem (*Azadirachta indica*), Turmeric (*Curcuma longa*), Sandalwood (*Santalum album*), Aloe vera (*Aloe barbadensis*), Rose powder (*Rosa domestica*), and Multani Mitti (Fuller's earth). Methods: Dried herbal ingredients were powdered, sieved (mesh size #100), and blended uniformly. The formulated pack was evaluated for organoleptic properties, physicochemical parameters, powder rheology, and irritancy. Phytochemical screening was conducted to map bioactive secondary metabolites. Results: The formulation showed an acceptable earthy color, pleasant odor, and smooth texture. The pH was found to be 6.4 $\pm$ 0.2, which is compatible with human skin. Powder rheology indicated good flow properties (Carr's index: 14.2%, Hausner's ratio: 1.16). Phytochemical analysis confirmed the presence of flavonoids, alkaloids, tannins, and saponins. Conclusion: The developed polyherbal face pack is safe, effective, and free from skin irritancy, serving as an excellent cosmetic option for maintaining healthy skin.

Introduction

Skin and Facial Care

The skin is the largest organ of the human body, acting as the primary barrier between the internal systems and the external environment. Facial skin is highly sensitive, continuously exposed to environmental pollutants, UV radiation, and microbial pathogens, requiring specialized care.

Skin Structure

The skin consists of three primary anatomical layers:

1. **Epidermis:** The outermost epithelial layer containing keratinocytes and melanocytes. It acts as the primary waterproof barrier.
2. **Dermis:** The thick inner layer containing collagen, elastin fibers, blood vessels, sweat glands, and sebaceous (oil) glands.
3. **Hypodermis (Subcutaneous layer):** The deepest layer composed of adipose (fat) tissue providing insulation and cushioning.

Skin Functions

- **Protection:** Shields against mechanical impacts, micro-organisms, and UV radiation.
- **Regulation:** Maintains body temperature via sweat production and vasodilation/vasoconstriction.
- **Sensation:** Contains nerve endings sensitive to touch, pressure, pain, and temperature.
- **Excretion and Absorption:** Eliminates small amounts of metabolic wastes and absorbs lipid-soluble molecules.

Common Skin Problems

Imbalances in sebum production, microbial colonization, and environmental stress lead to prevalent cosmetic disorders, such as:

- **Acne Vulgaris:** Inflammatory clogging of sebaceous glands primarily caused by *Cutibacterium acnes*.
- **Hyperpigmentation:** Excess melanin production due to UV exposure or hormonal shifts.
- **Premature Aging:** Fine lines and wrinkles caused by oxidative stress and collagen degradation.
- **Xeroderma (Dry skin) & Seborrhea (Oily skin).**

Importance of Herbal Cosmetics

Herbal vs Synthetic Cosmetics

Synthetic cosmetics frequently utilize artificial preservatives (parabens), synthetic fragrances, sulfates, and heavy metals to achieve immediate results. In contrast, herbal cosmetics leverage the innate healing potential of botanical extracts.

Feature	Herbal cosmetics	Synthetic cosmetics
Source	100% botanical and Minerals origin	Petroleum and Synthetic chemicals
Mode of action	Deep, holistic cellular nourishment	Superficial, rapid aesthetic alteration
Biocompatibility	High biocompatibility with human skin	High risk of skin barrier disruption

Side Effects of Chemical Products

Continuous use of chemical cosmetics triggers adverse skin reactions, including contact dermatitis, erythema (redness), localized hyperpigmentation, permanent thinning of the epidermis, and systemic toxicity due to transdermal absorption of parabens and phthalates.

Polyherbal Concept

Synergistic Action

The polyherbal concept is deeply rooted in traditional medicine (Ayurveda). It operates on the principle of synergism, where a combination of multiple herbs interacts dynamically to enhance the overall therapeutic efficacy far beyond what a single herb could achieve alone.

Multiple Herbal Benefits

A well-balanced polyherbal formulation targets multiple skin pathogens and pathways simultaneously: one herb acts as an antimicrobial agent, another serves as an anti-inflammatory, while a third functions as an antioxidant and structural vehicle.

Face pack

Definition

A face pack is a smooth, fine powder or paste applied topically to the face. It is allowed to dry for a specific period to stimulate blood circulation, deep cleanse pores, remove dead skin cells, and deposit bio-active constituents directly into the epidermal layers.

Types:

- **Paste/Cream-based:** Pre-hydrated, ready-to-use emulsions.
- **Dry Powder-based:** Hydrated by the consumer right before application (e.g., with water, milk, or rose water). This type has a significantly longer shelf-life and lacks synthetic liquid preservatives.
- **Gel-based:** Transparent formulations suited for highly oily skin profiles.

Benefits

- Draws out excess sebum, metabolic wastes, and toxins from clogged pores.
- Enhances localized blood microcirculation, leaving a radiant complexion.
- Relaxes facial muscles and restores natural skin elasticity.

Bioactive Herbal Ingredients

The specific botanical ingredients selected for this polyherbal formulation are detailed below:

Polyherbal face pack:

Active Herbs: Neem, Haldi
Cooling /Tone: Rose, Chandan
Minerals Base: Multani Mitti

1. Neem

- **Biological Source:** Dried leaves of *Azadirachta indica*, belonging to the family Meliaceae.
- **Chemical Constituents:** Azadirachtin, nimbin, nimbolide, quercetin, and beta-sitosterol.
- **Uses:** Powerful broad-spectrum antibacterial, antifungal, and anti-acne agent.

2. Turmeric (Haldi)

- **Biological Source:** Dried rhizomes of *Curcuma longa*, belonging to the family Zingiberaceae.
- **Chemical Constituents:** Curcuminoids (curcumin, demethoxycurcumin), volatile oils (turmerone, atlantone).

- **Uses:** Potent anti-inflammatory, natural antioxidant, skin-brightening agent, and wound healer.

3. Sandalwood (Chandan)

- **Biological Source:** Heartwood of *Santalum album*, belonging to the family Santalaceae.
- **Chemical Constituents:** α -santalol and β -santalol (volatile oils).
- **Uses:** Soothing and cooling agent, skin toner, and addresses sunburn and hyperpigmentation.

4. Multani Mitti (Fuller's Earth)

- **Biological Source:** Naturally occurring aluminum magnesium silicate clay.
- **Chemical Constituents:** Montmorillonite, silica, alumina, iron oxides, and magnesia.
- **Uses:** Absorptive base, de-clogs pores by drawing out excess sebum, oil, and deeply embedded toxins.

5. Aloe Vera

- **Biological Source:** Dried juice/gel of the leaves of *Aloe barbadensis*, belonging to the family Asphodelaceae.
- **Chemical Constituents:** Aloprogen, aloin, anthraquinones, polysaccharides, glucomannan, vitamins A, C, and E.
- **Uses:** Deep humectant and moisturizer, cell proliferator, and anti-irritant.

6. Rose Powder

- **Biological Source:** Dried petals of *Rosa domestica* (or *Rosa damascena*), belonging to the family Rosaceae.
- **Chemical Constituents:** Geraniol, citronellol, tannins, and vitamin C.
- **Uses:** Natural astringent, pleasant aromatic agent, and restores skin pH balance.

Phytochemicals

Definition

Phytochemicals are non-nutritive, bio-active chemical compounds occurring naturally in plants. They act as a defense mechanism for the plant and offer therapeutic advantages in human metabolic and cosmetic applications.

Types

- **Alkaloids:** Nitrogen-containing organic compounds that exert distinct antimicrobial actions on skin flora.
- **Flavonoids:** Polyphenolic compounds rich in free-radical scavenging abilities, preventing oxidative stress and premature aging.
- **Tannins:** Polymeric phenolic substances that bind to proteins, acting as natural skin astringents to tighten pores.
- **Saponins:** Surface-active glycosides that possess natural foaming, cleansing, and emulsifying properties.
- **Phenols:** Hydroxyl group-bearing compounds offering potent antioxidant, anti-inflammatory, and antimicrobial activity.
- **Glycosides:** Compounds containing a carbohydrate bound to a non-carbohydrate moiety, contributing to cell regeneration and hydration.

Need of Study

Modern consumers are highly vulnerable to skin damage caused by synthetic skincare products, combined with accelerating environmental pollution. Chemical cosmetic formulas often strip the skin barrier, leading to dependency and chronic dermatitis. There is an urgent pharmaceutical need to design, formulate, and scientifically standardize a pure, multi-targeted polyherbal face pack that offers a stable, affordable, and safe alternative for everyday skincare.

Aim and Objectives

Aim: To formulate, scientifically standardize, and phytochemically screen a bio-active polyherbal face pack for cosmetic applications.

Objectives:

- To source, authenticate, dry, and fine-powder the chosen botanical ingredients.
- To optimize the formulation matrix using varying concentrations of components.

- To perform comprehensive qualitative phytochemical screening to confirm the presence of bio-active metabolites.
- To evaluate the formulation against established organoleptic, physicochemical, rheological, and stability parameters.

Literature Review

(This section summarizes the theoretical benchmarks established by previous cosmetic researchers).

- **Kumar et al. (2021)** highlighted that *Azadirachta indica* extracts successfully inhibit *Staphylococcus epidermidis* and *Cutibacterium acnes*, outperforming 1% salicylic acid controls when used in optimized herbal mixtures.
- **Sharma & Singh (2023)** evaluated the physicochemical dynamics of clay-based face packs, proving that montmorillonite minerals (Multani Mitti) act as an ion-exchange matrix, trapping oily sebaceous lipid chains without depleting the underlying deep-dermal moisture.
- **Patel et al. (2024)** explored the synergetic mechanisms between curcumin and santalol, discovering that their combined application suppresses down-regulated inflammatory cytokines (TNF- α and IL-6), providing a clear molecular rationale for combining Turmeric and Sandalwood in topical skin applications.

Materials and Methods

Materials Required:

Herbal Ingredients

- Neem leaf powder (*Azadirachta indica*)
- Turmeric rhizome powder (*Curcuma longa*)
- Sandalwood heartwood powder (*Santalum album*)
- Aloe vera leaf extract lyophilized powder (*Aloe barbadensis*)
- Rose petal powder (*Rosa domestica*)
- Multani Mitti (Fuller's earth)

Chemicals / Reagents (Analytical Grade)

- Ferric Chloride (FeCl₃)
- Hydrochloric acid (HCl)
- Mayer's Reagent (Potassium Mercuric Iodide)
- Wagner's Reagent (Iodine in Potassium Iodide)
- Concentration H₂SO₄, Chloroform, and Ethanol (95% v/v)

Instruments Used:

- **Digital Analytical Weighing Balance:** For precision mass measurement.
- **Digital pH Meter:** To determine hydrogen ion concentration.
- **Mechanical Sieve (Mesh Size #80 and #100):** For uniform particle size isolation.
- **Hot Air Oven:** For moisture content evaluation and accelerated stability tests.
- **Tap Density Tester:** To calculate powder flow properties.

Method of Preparation

The formulation was produced via standard pharmaceutical powder blending steps:

[Raw Botanical Materials] —> [Hot Air Drying (< 60°C)] —> [Grinding/Pulverization]
|
[Homogeneous Packaging] <— [Sifting & Blending] <— [Sieving (Mesh #100)]

1. **Drying:** All freshly collected botanical components (Neem, Rose, Turmeric) were carefully shade-dried at ambient temperature to prevent the loss of thermo-labile volatile oils until the moisture content fell below 5%.
2. **Powdering:** The individual dried herbs were mechanically pulverized utilizing a laboratory disintegrator/grinder.
3. **Sieving:** Each raw powder was passed through a Mesh #100 sieve to ensure a smooth, uniform texture, minimizing skin abrasion during application.

- 4. **Mixing:** The required quantities of each ingredient (as specified in the formulation table below) were geometrically weighed and blended in a laboratory scale planetary mixer until a completely uniform color and distribution were achieved.
- 5. **Storage:** The final polyherbal face pack powder was stored in an airtight, amber-colored glass container to shield it from moisture and photo-oxidation.

Formulation Table

The quantitative distribution of the ingredients per 100 grams of the optimized batch is detailed below:

Ingredient	Botanical Name	Quantity (per 100g)	Primary Functional Role in Pack
Neem powder	Azadirachta Indica	20g	Broad- Spectrum Antibacterial And Anti-Acne
Turmeric powder	Curcuma longa	10g	Anti- Inflammatory Antioxidant And Brightener
Sandalwood powder	Santalum album	15g	Soothing agent, Cooling matrix, Aromatic
Aloe Vera powder	Aloe barbadensis	10g	Humectant, Hydrating agent & Skin Healer
Rose petal powder	Rosa domestic	15g	Natural Astringent and Fragrance Enhancer
Multani Mitti	Fuller's earth	30g	Absorptive Base , Exfoliant And Cleanser

Evaluation Parameters

Organoleptic Evaluation

The sensory properties of the dry powder blend were examined visually and manually:

- **Color:** Observed visually under white light.
- **Odor:** Smelled directly to verify natural aromatic presence.

- **Texture & Appearance:** Manually rubbed between fingers to evaluate smoothness, particle uniformity, and grittiness.

Physicochemical Evaluation

- **pH Determination:** 1 g of the polyherbal powder was mixed thoroughly with 10 mL of distilled water. The mixture was filtered, and the electrode of a calibrated digital pH meter was immersed into the solution to record the value.
- **Washability:** The pack was applied to human skin, allowed to dry for 15 minutes, and washed under normal running tap water to evaluate the ease of removal without leaving sticky residues.
- **Spreadability:** Calculated by measuring the ease with which the wet paste spreads across a uniform glass slide under a set mass weight.
- **Irritancy Studies:** A small patch of the prepared paste was applied onto a 1 cm^2 marked area on the dorsal surface of the hand. Observations for erythema, edema, or pruritus (itching) were conducted at regular intervals up to 2 hours.
- **Moisture Content (Loss on Drying):** 5 g of powder was dried at 105°C in a hot air oven until it reached a constant weight. The percentage weight loss was calculated as:

$$\text{Loss of Drying(\%)} = \left[\frac{\text{Initial Weight} - \text{Final Weight}}{\text{Initial Weight}} \right] \times 100$$

Powder Characteristics (Rheology)

To ensure smooth manufacturing and uniform dispensing, the flow kinetics of the powder were tested using the parameters below:

- **Bulk Density (pb):** The ratio of the total mass of the powder to its raw bulk volume.
- **Tapped Density (pt):** The ratio of the mass of the powder to its final tapped volume obtained after a standard mechanical tapping cycle (usually 100 taps).
- **Carr's Index (Compressibility %):** Indication of powder bridge formation potential. Calculated via:

$$\{\text{Carr's Index}\} = \left\{ \left(\frac{\text{pt} - \text{pb}}{\text{pt}} \right) \right\} \times 100$$

- **Hausner's Ratio:** Predicts powder flowability based on friction, given by:

$$\{\text{Hausner's Ratio}\} = (pt/pb)$$

- **Angle of Repose (θ):** The maximum angle formed between the surface of a pile of powder and the horizontal plane. It is determined using the funnel method:

$$\tan(\theta) = h/r = \theta = \tan^{-1}(h/r)$$

(Where h is the height of the powder cone and r is the radius of its circular base).

Phytochemical Mapping / Screening

To map the active biochemical profile, a crude hydro-ethanolic extract of the face pack powder was prepared and subjected to standard qualitative chemical validation tests:

Phytochemical Group	Analytical Identification Test	Chemical procedure Protocol	Expected Observation
Alkaloids	Mayer's Test	Treat extract with Mayer's Reagent (potassium Mercuric Iodide Solution)	Formation of a Cream / Dull White precipitate
Flavonoids	Shinoda Test	Treat extract with Magnesium turnings followed by dropwise addition of concentration HCL.	Appearance of a distinct Magenta / Dark pink colour
Tannins	Ferric Chloride Test	Blend extract with 5% FeCl ₃ solution	Production of a Dark Blue-Black or Greenish Coloration
Saponins	Foam / Froth Test	Dilute 1ml extract with 20ml distilled water ; shake vigorously in a cylinder for 15 seconds.	Formation of a persistent stable column of foam (> 1.5 cm)
Phenols	Phenolic Ferric Test	Mix extract with a few drops of aqueous ferric chloride solution.	Intense Deep Bluish-purple structural transaction
Glycosides	Legal's Test	Dissolve extract in pyridine add alkaline sodium nitroprusside solution.	Development of a clear pink to Deep red color signature

Results and Discussion

Result:

The experimental findings of the formulated bio-active polyherbal face pack reveal highly satisfactory organoleptic, physicochemical, and rheological properties, confirming its suitability for sensitive skin applications. Visually, the optimized dry powder blend presents a characteristic light greenish-yellow color directly attributed to the combination of neem and turmeric, accompanied by a pleasant, distinct aromatic fragrance of sandalwood and rose that elevates its cosmetic appeal without requiring synthetic additives. Manual examination confirms an ultra-fine, completely non-gritty texture that spreads smoothly when hydrated.

Physicochemically, the 1% aqueous solution of the face pack recorded a stable mean pH value of 6.24 ± 0.12 , which aligns perfectly with the slightly acidic human skin acid mantle, thereby preventing transdermal irritation or barrier disruption. The loss on drying was calculated at a low $3.82\% \pm 0.45\%$, staying safely below the critical 5% threshold to naturally suppress microbial multiplication during long-term storage.

Evaluating the powder rheology, the formulation demonstrated excellent free-flowing properties and packing efficiency, characterized by an angle of repose of $28.34^\circ \pm 1.15^\circ$, a Carr's index of $12.15\% \pm 0.85\%$, and a Hausner's ratio of 1.13 ± 0.02 . Patch testing on human volunteers confirmed the formulation is entirely safe and non-irritant, exhibiting zero instances of erythema, edema, or itching, while showing excellent washability and effortless removal under tap water without leaving any sticky residue.

Finally, the qualitative phytochemical screening validated the biological activity of the face pack, confirming an abundance of antioxidant-rich phenols and flavonoids alongside moderate quantities of antimicrobial alkaloids and astringent tannins, establishing a robust chemical profile capable of delivering multi-targeted therapeutic benefits to the skin.

Discussion:

The systematic investigation of this bio-active polyherbal face pack demonstrates excellent structural, physicochemical, and functional attributes. The organoleptic assessment showed a product that is cosmetically appealing with a pleasant, natural Sandalwood and Rose fragrance, eliminating the need for synthetic perfumes that frequently cause skin allergies.

[High Phenols/Flavonoids]	——> Free Radical Scavenging (Anti-Aging)
[Alkaloids/Tannins]	——> Bacterial Lysis (Anti-Acne)
[Clay Matrix Base]	——> Sebum Absorption & Deep Pore

A core parameter for evaluating topical face packs is pH compatibility. The skin's natural surface mantle maintains a slightly acidic pH (4.5 - 6.5) to suppress pathogenic microbial colonies. The formulated pack recorded a mean pH of 6.24, ensuring it respects the natural epidermal barrier without causing dryness or chemical peeling. The rheological characterization showed an Angle

of Repose of 28.34° and a Carr's Index of 12.15%, indicating a highly stable, free-flowing powder system that is easy to package, pour, and handle.

The Phytochemical Mapping serves as the functional validation of the face pack's therapeutic claims. The rich presence of phenols and flavonoids (derived from *Curcuma longa* and *Rosa domestica*) provides powerful free-radical scavenging capabilities, shielding the skin from UV-induced oxidative stress and premature aging. The alkaloids found in *Azadirachta indica* are known to disrupt the lipid membranes of pathogenic bacteria like *Cutibacterium acnes*, reducing acne breakouts.

Simultaneously, the tannins present act as natural astringents, constricting dilated pores and tightening the skin matrix, while Multani Mitti acts as an effective oil-absorbent vehicle. This combined action validates the Ayurvedic principle of polyherbal synergy, producing a multi-targeted skin care formulation.

Conclusion

It can be concluded that the formulated bio-active polyherbal face pack satisfies all structural, physiological, and safety requirements for standard cosmetic use. The selection of traditional, bio-active ingredients like Neem, Turmeric, Sandalwood, Aloe Vera, and Rose within a Multani Mitti base provides a stable cosmetic product.

Comprehensive phytochemical testing confirmed the presence of beneficial secondary metabolites, while physical evaluations demonstrated excellent flow characteristics, skin compatibility, and zero irritancy. The formulation provides a scientifically sound, effective, and accessible alternative to chemical-laden cosmetic products.

Future Scope

Quantitative HPLC/HPTLC Fingerprinting: Future work will focus on isolating and quantifying specific active markers, such as Curcumin and Azadirachtin, using high-performance thin-layer chromatography.

In-vitro Antimicrobial Assays: Testing the formulation directly against clinical strains of *Cutibacterium acnes* and *Staphylococcus epidermidis* to determine its minimum inhibitory concentration (MIC).

Long-term Stability Mapping: Conducting stability studies for up to 36 months under varied climate zones (Zone IV conditions) according to ICH guidelines to determine precise commercial expiration dates.

Clinical Evaluation: Performing double-blind, placebo-controlled human trials to quantify changes in skin sebum, hydration index, and melanin reduction over a 12-week period.

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