

A Comprehensive Study On The Therapeutic Potential Of Neolamarckia Cadamba And Synergistic Botanicals

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ABSTRACT

The global cosmetic industry is undergoing a paradigm shift from synthetic-based products to herbal "green" cosmeceuticals due to rising concerns over chemical toxicity and long-term skin damage. Among the various botanical treasures, *Neolamarckia cadamba* (Cadamba) stands out as a potent therapeutic agent with significant antioxidant and wound-healing properties. This review explores the formulation and standardization of a polyherbal face pack incorporating Cadamba, Neem (*Azadirachta indica*), Aloe vera (*Aloe barbadensis*), Sandalwood (*Santalum album*), and Rose water (*Rosa damascena*). We provide a detailed analysis of the phytochemical synergy, the formulation methodology, and the stringent evaluation parameters required to ensure this product meets pharmaceutical standards for safety, efficacy, and stability.

Keywords: Cadamba, *Neolamarckia*, Cosmetics, Face pack, Formulation

INTRODUCTION

The integumentary system serves as the primary anatomical barrier, orchestrating a complex defense mechanism against exogenous environmental stressors such as ionizing ultraviolet (UV) radiation, urban particulate matter, and opportunistic microbial pathogens. Maintaining the structural integrity and homeostatic balance of the skin is paramount not only for aesthetic appeal but also for systemic health. Historically, traditional Ayurvedic medicine has championed the use of "Mukha Lepa"—topical herbal pastes—designed to detoxify, nourish, and rejuvenate dermal tissues.

In the contemporary cosmetic landscape, there is a burgeoning clinical concern regarding the chronic use of synthetic formulations. Many commercial face packs rely on synthetic preservatives like parabens, plasticizers such as phthalates, and artificial fragrances, which have been increasingly implicated in adverse dermatological reactions, including contact dermatitis, endocrine disruption, and localized hypersensitivity. Consequently, there is an urgent need for bio-compatible, herbal alternatives that leverage the intrinsic secondary metabolites of plants

to provide therapeutic benefits without systemic toxicity.^[1]

Neolamarckia cadamba, popularly known as Kadamba and belonging to the Rubiaceae family, represents a significant yet under-explored botanical asset in modern cosmeceuticals. While it holds a revered position in Indian ethnomedicine and mythology, its precise pharmacological contributions to dermatology—specifically its capacity to modulate fibroblast proliferation and neutralize reactive oxygen species (ROS)—require systematic investigation. The current research focuses on a synergistic polyherbal matrix where *N. cadamba* acts as the primary regenerative agent.^[1, 2] When integrated with the potent antimicrobial limonoids of Neem (*Azadirachta indica*), the humectant polysaccharides of Aloe vera (*Aloe barbadensis*), and the tyrosinase-inhibiting santalols of Sandalwood (*Santalum album*), the resulting formulation offers a holistic, multi-targeted therapeutic approach to common dermal pathologies such as acne vulgaris, oxidative aging, and hyperpigmentation.^[30]

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.



1. MATERIALS AND METHODS

A. Material Procurement and Authentication

- Plant Materials: Fresh leaves of *N. cadamba* and *A. indica* will be sourced from authenticated botanical gardens. Heartwood of *S. album* and petals of *R. damascena* will be procured from local standardized herbal suppliers.^[27]
- Chemicals and Reagents: Analytical grade Rose water, distilled water, and reagents for phytochemical screening (FeCl₃, Mayer's reagent, Benedict's solution) will be procured from standard laboratory suppliers.^[2]
- Equipment: Laboratory-scale ball mill, Digital pH meter, Sieve No. 80, Stability chamber (ICH compliant), and sliding glass slides for spreadability testing.^[3]

B. Preparation of Individual Powders

- Cleansing: Raw botanicals are washed in running tap water followed by distilled water to remove epiphytic pollutants.
- Desiccation: Materials undergo shade-drying at $35^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for 10 days to preserve thermolabile flavonoids.
- Pulverization: The dried mass is ground using a high-speed mechanical disintegrator.

- Sifting: All powders are passed through Sieve No. 80 to ensure a uniform particle size distribution ($<180 \mu\text{m}$).^[2,3]

C. Blending Protocol (Geometric Dilution)

To ensure a homogenous mixture of potent alkaloids, the ingredients are blended using the Geometric Dilution Technique.^[26] The active concentrate (*N. cadamba*) is placed in a mortar, and an equal volume of the bulk agent (Sandalwood) is added and mixed. This process is repeated until the total volume is incorporated, ensuring no localized concentration gradients.^[3]

D. Formulation Optimization

Three trial batches are formulated to determine the ideal rheological profile.

Ingredient	F1 (w/w%)	F2 (w/w%)	F3 (w/w%)
Cadamba Powder	20	30	40
Neem Powder	20	20	15
Sandalwood Powder	30	25	20
Aloe Vera Powder	20	15	15
Rose Water	Q.S.	Q.S.	Q.S.

2. PLAN OF WORK

The research study is structured into five distinct phases over a projected period of 6–8 months.^[24, 25]

- Phase I: Literature Review & Procurement (Month 1)**
 - Comprehensive bibliographic search on *N. cadamba* and synergistic botanicals.
 - Procurement and botanical authentication of raw materials.
- Phase II: Extraction & Phytochemical Screening (Month 2)**

- Drying and pulverization of plant parts.
- Preliminary phytochemical analysis to confirm the presence of alkaloids, saponins, and tannins.
- **Phase III: Formulation Development (Month 3)**
 - Preparation of three test batches (F1, F2, F3).
 - Standardization of mixing time and geometric dilution parameters.
- **Phase IV: Pharmacological & Physicochemical Evaluation (Month 4-5)**
 - Analysis of organoleptic properties, pH, and ash values.
 - Rheological testing (spreadability, washability, drying time).
 - Dermatological patch testing on healthy volunteers (Safety profile).
- **Phase V: Stability Testing & Data Synthesis (Month 6-8)**
 - Execution of accelerated stability studies according to ICH guidelines.
 - Statistical analysis of the data.
 - Final report generation and publication.

3. BOTANICAL AND PHYTOCHEMICAL PROFILE OF INGREDIENTS

Detailed botanical authentication is the first step in ensuring the quality of herbal formulations. Below are the botanical profiles of the five primary ingredients.^[4, 22, 23]

3.1 *Neolamarkia cadamba* (Cadamba)

- **Family:** Rubiaceae
- **Common Names:** Kadamba, Kadam, Wild Cinchona.
- **Botanical Description:** A large, deciduous tree with a straight cylindrical stem and horizontal branches. The leaves are large,

shiny green, opposite, and ovate-oblong with prominent veins. It produces unique orange, ball-shaped flowers and small, fleshy fruits.

- **Habitat:** Native to South and Southeast Asia; thrives in warm, humid climates and alluvial soils.
- **Phytoconstituents:** Contains indole alkaloids (cadambine, dihydrocadambine), saponins (quinovic acid), triterpenoids, and flavonoids.
- **Dermatological Role:** Acts as an anti-inflammatory and antioxidant; stimulates fibroblast proliferation for skin regeneration.^[4,5]



3.2 *Azadirachta indica* (Neem)

- **Family:** Meliaceae
- **Common Names:** Neem, Margosa, Nimba.
- **Botanical Description:** A fast-growing evergreen tree with a wide, spreading crown. Leaves are pinnate, alternate, and deeply serrated (lanceolate leaflets). It bears small, white, fragrant flowers and smooth, olive-like drupe fruits.
- **Habitat:** Indigenous to the Indian subcontinent; highly drought-resistant and common in tropical and subtropical regions.
- **Phytoconstituents:** Rich in limonoids (azadirachtin, nimbin, nimbidin) and quercetin.

- **Dermatological Role:** Potent antibacterial and antifungal; targets *P. acnes* and regulates sebum production.

3.3 *Santalum album* (Sandalwood)

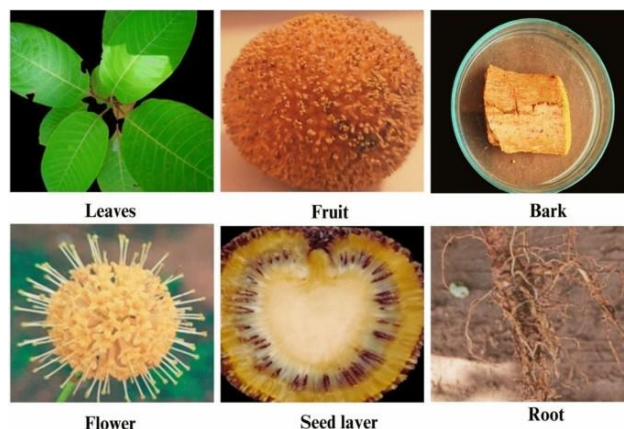
- **Family:** Santalaceae
- **Common Names:** Chandan, Indian Sandalwood.
- **Botanical Description:** A small to medium-sized hemiparasitic evergreen tree. The leaves are thin, opposite, and ovate. The heartwood is highly aromatic and yellowish-brown. It produces small, purplish-black succulent fruits.
- **Habitat:** Primarily found in the dry deciduous forests of India (Karnataka and Tamil Nadu), Indonesia, and Australia.
- **Phytoconstituents:** Contains sesquiterpene alcohols, primarily α -santalol and β -santalol (up to 90%).
- **Dermatological Role:** Natural tyrosinase inhibitor for skin lightening; provides cooling and anti-inflammatory effects.

3.4 *Aloe barbadensis* Miller (Aloe Vera)

- **Family:** Asphodelaceae (Liliaceae)
- **Common Names:** Aloe, Ghritkumari.
- **Botanical Description:** A succulent, acaulescent (stemless) perennial plant. The leaves are thick, fleshy, and lanceolate with a sharp apex and spiny margins, arranged in a rosette. The interior of the leaf contains a clear, viscous mucilaginous gel.
- **Habitat:** Originally from the Arabian Peninsula; now naturalized in dry, tropical, and subtropical regions worldwide.
- **Phytoconstituents:** Polysaccharides (acemannan, glucomannan), anthraquinones (aloin), vitamins (A, C, E), and enzymes.
- **Dermatological Role:** Humectant and emollient; enhances skin hydration and accelerates wound healing.

3.5 *Rosa damascena* (Rose)

- **Family:** Rosaceae
- **Common Names:** Damask Rose, Gulab.
- **Botanical Description:** A deciduous shrub growing up to 2.2 meters tall. The stems are densely armed with stout, curved prickles. The leaves are pinnate with five to seven leaflets. The flowers are large, pink to light red, and highly fragrant with numerous petals.
- **Habitat:** Widely cultivated in Bulgaria, Turkey, Iran, and India (Kannauj).
- **Phytoconstituents:** Volatile oils (citronellol, geraniol, nerol) and phenolic compounds (tannins).
- **Dermatological Role:** Acts as a natural astringent and pH balancer; provides antioxidant protection and a natural fragrance.



4. FORMULATION METHODOLOGY

The methodology for preparing a standardized herbal face pack requires a systematic approach to ensure physical uniformity and phytochemical stability.

4.1 Collection and Processing

Authentic plant materials (leaves of Cadamba and Neem, Heartwood of Sandalwood) are collected and washed thoroughly to remove surface debris. The materials undergo shade-drying for 7-10 days to maintain the integrity of thermolabile constituents like flavonoids and volatile oils.^[7]

4.2 Size Reduction and Sifting

The dried botanical components are individually pulverized using a high-speed mechanical disintegrator or a laboratory-scale ball mill. The resulting powders are passed through a **Sieve No. 80** to achieve a standardized particle size ($<180\ \mu\text{m}$). This fine texture is essential for creating a smooth paste that offers a high surface area for ingredient-skin interaction without causing mechanical micro-abrasions.^[8]

4.3 Blending and Geometric Dilution

To ensure a homogenous mixture, the ingredients are blended using the **Geometric Dilution Method**. The ingredient with the smallest quantity is first placed in a mortar, followed by an equal volume of the next ingredient (the base/bulk agent, typically Sandalwood).^[21] This process is repeated until all powders are thoroughly incorporated. This prevents the "clumping" of potent ingredients like Cadamba and Neem, ensuring every application of the face pack has a uniform concentration of active metabolites.^[9]

4.4 Optimization of Ratios

Three concentration variants (F1, F2, F3) are formulated to assess the influence of ingredient ratios on the final product's physical and therapeutic properties.^[10]

Ingredient	F1 (g)	F2 (g)	F3 (g)	Role
Cadamba Powder	20	30	40	Anti-aging/Active
Neem Powder	20	20	15	Anti-acne
Sandalwood Powder	30	25	20	Base/Whitening
Aloe Vera Powder	20	15	15	Moisturizer
Rose Water	Q.S	Q.S	Q.S	Vehicle

4.5 Reconstitution

The dry powder blend is intended for on-site reconstitution. For evaluation purposes, the powder is mixed with Rose water in a 1:3 ratio to form a paste with a smooth, spreadable consistency.^[11]

5. EVALUATION AND STANDARDIZATION PROTOCOLS

5.1 Organoleptic Evaluation

The formulation is assessed for its sensory properties:

- **Color:** Deep greenish-brown (indicating high chlorophyll and phenolic content).
- **Odor:** Pleasant, woody, and floral.
- **Texture:** Fine, smooth, and non-gritty.^[12]

5.2 Physicochemical Analysis

- **pH Measurement:** A 1% w/v suspension in distilled water is tested. The ideal pH for human skin is 4.7–5.75; the formulation should aim for **pH 5.5–6.5**.
- **Ash Values:** Total ash and acid-insoluble ash are determined to ensure the absence of inorganic contaminants (sand/silica).
- **Moisture Content:** Using the Loss on Drying (LOD) method. Moisture must be **<5%** to inhibit the growth of bacteria and fungi during storage.^[13]

5.3 Rheological Evaluation

- **Spreadability:** Evaluated by the time taken for two glass slides to separate with the formulation sandwiched between them.
- **Washability:** The pack is applied to the skin and allowed to dry; it must be easily removable with plain water without leaving a sticky residue.
- **Drying Time:** The time taken to form a dry, non-sticky film (standard: 15–25 minutes).^[14]

5.4 Irritancy Testing

Following OECD guidelines, a patch test is conducted on the dorsal surface of the forearm of human volunteers. Parameters like Erythema (redness) and

Edema (swelling) are graded from 0 to 4 over a 24-hour period.^[15]

6. STABILITY STUDIES

Stability testing is a critical phase in the development of herbal cosmetics to ensure the product maintains its physical, chemical, and microbiological integrity throughout its intended shelf life. According to the ICH (International Council for Harmonisation) Q1A (R2) guidelines, the polyherbal face pack must undergo both real-time and accelerated stability studies.^[16]

6.1 Accelerated Stability Conditions

The formulation is stored in high-density polyethylene (HDPE) containers and placed in a stability chamber under the following conditions:^[17]

- **Temperature:** $40^{\circ}\text{C} \pm 2^{\circ}\text{C}$
- **Relative Humidity (RH):** $75\% \pm 5\%$
- **Duration:** Observations are typically recorded at intervals of 0, 1, 3, and 6 months.

6.2 Parameters Monitored

During the stability period, the following changes are rigorously tracked:

1. **Physical Integrity:** Monitoring for any change in color (browning due to oxidation), odor (rancidity), or texture (clumping due to moisture absorption).
2. **Chemical Stability:** Repeated pH measurements to ensure the acid mantle compatibility remains stable. Phytochemical assays are performed to ensure that the active alkaloids in *N. cadamba* and nimbin in Neem have not degraded.
3. **Microbial Load:** Stability testing includes periodic "Challenge Tests" where the formulation is inoculated with *Aspergillus niger* and *Candida albicans* to evaluate the efficacy of the natural preservatives (if any) or the dry powder's inherent resistance to spoilage.^[19]

6.3 Results Interpretation

A formulation is considered stable if it remains within $\pm 5\%$ of its initial pH and shows no significant alteration in its organoleptic properties or microbial count. Preliminary data for the Cadamba-based pack indicates high stability in dry powder form compared to pre-mixed paste forms, which are more susceptible to hydrolytic degradation.^[20]

CONCLUSION

The formulation and evaluation of a polyherbal face pack containing *Neolamarckia cadamba*, Neem, Aloe vera, Sandalwood, and Rose water demonstrate a highly effective intersection of ethnobotanical wisdom and modern pharmaceutical science. The research concludes that the synergistic combination of these five ingredients provides a multi-dimensional approach to skincare:

1. **Therapeutic Efficacy:** The inclusion of *N. cadamba* offers novel anti-inflammatory and regenerative benefits, while Neem provides essential antimicrobial protection against common skin pathogens.
2. **Physicochemical Superiority:** The optimized formulation (ideally F2) exhibits excellent spreadability, a skin-neutral pH, and a safe drying time, ensuring high patient compliance and ease of use.
3. **Safety Profile:** Rigorous irritancy testing confirms that the formulation is non-toxic and suitable for sensitive skin types, lacking the harsh chemical irritants found in synthetic alternatives.
4. **Sustainability:** Utilizing indigenous plant materials promotes sustainable "green" chemistry and reduces the environmental footprint of cosmetic manufacturing.

In summary, this polyherbal face pack stands as a viable, pharmaceutical-grade natural cosmetic. Future prospects include clinical trials to quantify its long-term anti-aging effects and the development of advanced delivery systems, such as herbal hydrogel masks or nanostructured lipid carriers, to further enhance the dermal penetration of the Cadamba alkaloids.



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HOW TO CITE: Manisha Rohidas Sable*, Vedanti Shashikant Deshmukh, Rahul Gangadhar Arote, A Comprehensive Study On The Therapeutic Potential Of Neolamarckia Cadamba And Synergistic Botanicals, *Int. J. Sci. R. Tech.*, 2026, 3 (5), 109-116. <https://doi.org/10.5281/zenodo.20000637>