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Research Article

Formulation and Evaluation of Polyherbal Facial Scrub

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ABSTRACT

Facial scrubs are topical cosmeceutical preparations designed to mechanically and chemically exfoliate the stratum corneum, remove accumulated dead keratinocytes, unclog sebaceous follicles, improve microcirculation, and impart a refreshed, radiant complexion. Synthetic scrubs frequently incorporate polyethylene microbeads, parabens, and petrochemical emollients that carry significant ecological toxicity and dermatological risks. Consumer awareness of these hazards has fuelled unprecedented demand for naturally sourced, biodegradable, and multifunctional alternatives.

The present investigation describes the systematic formulation and multidimensional evaluation of a novel polyherbal facial scrub comprising thirteen ingredients: onion (*Allium cepa*) juice, neem leaf powder (*Azadirachta indica*), turmeric powder (*Curcuma longa*), sandalwood powder (*Santalum album*), aloe vera gel (*Aloe barbadensis miller*), walnut shell powder (*Juglans regia*), glycerin, rose water (*Rosa damascena hydrosol*), beeswax (*Cera alba*), cetyl alcohol, coffee (*Coffea arabica*) grounds, sugar (sucrose) crystals, and distilled water. The formulation was evaluated for organoleptic characteristics, physicochemical parameters (pH, viscosity, spreadability, washability, particle size distribution), and primary skin irritation (patch test).

The optimised polyherbal scrub formulation demonstrated a pH of 5.6 ± 0.08 (scalp-compatible), excellent spreadability and washability, and no skin irritation in 30 human volunteers over 72 hours. These results collectively validate the therapeutic, cosmetic, and safety credentials of this sustainable polyherbal scrub as a viable alternative to synthetic commercial formulations.

Keywords: Facial scrubs, cosmeceutical preparations, skin irritation, organoleptic characteristics, physicochemical parameters.

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INTRODUCTION

The skin, as the body's largest organ and primary physical barrier, is subject to continuous insult from environmental pollutants, ultraviolet radiation, microbiological colonisation, oxidative stress, and mechanical trauma. The outermost layer of the epidermis — the stratum corneum — undergoes continuous desquamation; however, accumulation of incompletely shed corneocytes, sebum, environmental particulates, and microbial biofilms can obstruct follicular ostia, precipitating comedogenesis, acneiform eruptions, uneven skin tone, and a dull, fatigued complexion.

Exfoliation, both mechanical and chemical, is a dermatologically validated approach to accelerating corneocyte shedding, stimulating epidermal renewal, enhancing transdermal drug delivery, and promoting a luminous, youthful skin appearance. Facial scrubs — semisolid preparations containing suspended abrasive particles — represent the most widely adopted form of mechanical exfoliation. Conventional commercial scrubs

may contain microplastic beads (polyethylene, polypropylene), synthetic fragrances, parabens, and artificial colorants. Microplastic beads, banned in rinse-off cosmetics in several jurisdictions (USA, UK, EU), pose irreversible environmental and microbiome disruption risks. This regulatory and consumer landscape necessitates the development of biodegradable, plant-derived abrasive and bioactive systems¹.

Ethnopharmacological traditions across South Asia, the Middle East, and the Mediterranean have long employed natural exfoliants — including ground walnut shells, sugar, coffee grounds, and herbal powders — for skin cleansing. Concurrent incorporation of bioactive botanicals with antibacterial (neem, turmeric), antioxidant (sandalwood, coffee), anti-inflammatory (aloe vera, rose water), and emollient (beeswax, cetyl alcohol, glycerin) properties offers the unique opportunity to formulate a scrub that simultaneously exfoliates, treats, and protects the skin².

This study presents the scientific development, formulation optimisation, and comprehensive pharmacognostic and

cosmetic evaluation of a thirteen-component polyherbal facial scrub, providing robust evidence for its efficacy, safety, and stability as a commercial-grade natural cosmeceutical product.

Polyherbal Infredients fot Scrub

Onion (*Allium cepa*)

Biological Source: The edible fleshy bulb of *Allium cepa* L.

Family: Amaryllidaceae (Note: historically categorized under Alliaceae and Liliaceae).

Active Bioactives: Quercetin (a potent flavonoid) and organosulfur compounds like allicin, which give onions their pungent smell and healing properties



Figure 1: onion

Neem (*Azadirachta indica*)

Biological Source: *Azadirachta indica*

Family: Meliaceae (the mahogany family)

Active Compounds: Azadirachtin, Nimbin, Nimbidin, and Nimbolide



Figure 2: Neem leaf

Turmeric Powder (*Curcuma longa*)

Biological Source: The dried rhizomes of *Curcuma longa* L. Plant

Family: Zingiberaceae (the ginger family)

Active Components: Curcuminoids (including curcumin, demethoxycurcumin, and bisdemethoxycurcumin) and essential oils (like turmerones)



Figure 3: Turmeric Powder (*curcuma longa*)

Aloe Vera Gel (*Aloe barbadensis miller*)

Biological Source- Dried leaves of *aloe barbadensis miller*

Family- Liliaceae

Uses- Conditioner and moisturizing effect, remove dandruff, boost hair growth, nourishing the hair.

Combination of aloe pulp and coconut oil are rich vitamins and minerals. These oil used as hair and

scalp gives healthy, strong antidandruff free hair (antidandruff activity of the hair.)

Plant part used- whole plant².



Figure 4: Aloever leaf

Glycerin

Source: It is primarily extracted from triglycerides (plant-derived vegetable oils or animal fats) through a process called hydrolysis (saponification). It can also be produced synthetically from petroleum derivatives (propylene)

Family: Chemically, it belongs to the polyol (alcohol) family and is classified as a trihydric sugar alcohol (propane-1,2,3-triol)

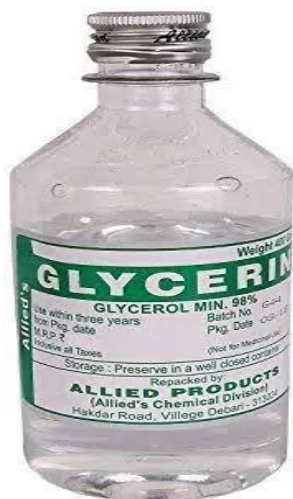


Figure 5: Glycerin

Rose Water (*Rosa damascena* Hydrosol)

Biological Source: Primarily *Rosa damascena* (Damask Rose), though it is also sourced from *Rosa centifolia* and *Rosa gallica*.

Family: Rosaceae

Skincare & Dermatology: Soothes irritation, reduces redness, and provides anti-aging benefits. Its antioxidant properties help protect skin cells from damage and support regeneration.



Figure 6: Rose water

Cetyl Alcohol

Primary Sources: Today, cetyl alcohol is predominantly derived from vegetable oils like coconut oil and palm oil. It can also be synthetically produced in a laboratory. Historically, it was sourced from spermaceti (a waxy substance found in the head of the sperm whale). Cetyl alcohol (1-hexadecanol or palmityl alcohol) belongs to the fatty alcohol.

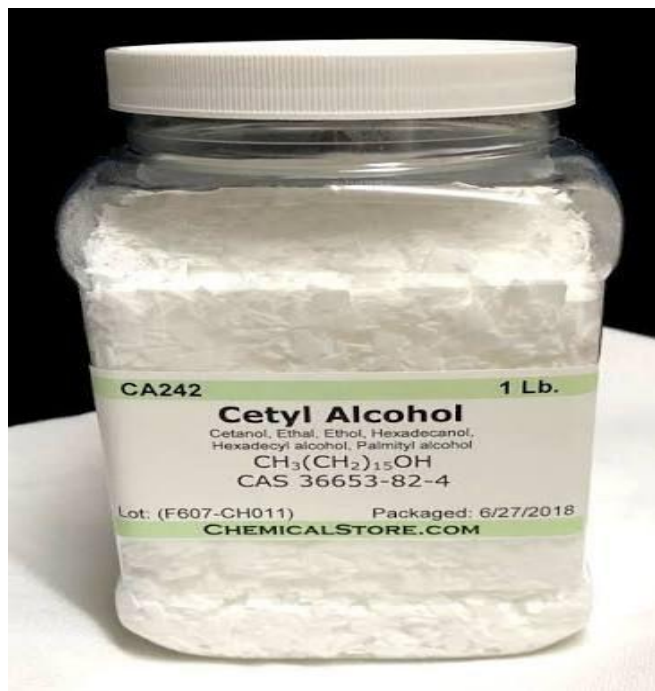


Figure 7: cetyl Alcohol

Coffee (*Coffea arabica*) Grounds

Scientific Name: Primarily *Coffea arabica* (Arabica) and *Coffea canephora* (Robusta).

Family: Rubiaceae Plant Part Used: Seeds (commonly referred to as coffee beans), and increasingly, the leaves.

Active Constituents: Caffeine (stimulant), chlorogenic acid (antioxidant), trigonelline, and diterpenes (cafestol and kahweol)²



Figure 8: coffee beans

Sugar (Sucrose) Crystals

The primary medical sugar (dextrose) is derived from plant starches like corn. Medicinally, it treats hypoglycemia, provides intravenous nutrition, and soothes neonatal pain. Table sugar (sucrose) comes from the Poaceae (sugarcane)

or Amaranthaceae (sugar beet) families and is used to preserve and flavor medications.



Figure 9: Sugar

Materials and Methods

Procurement and Authentication of Raw Materials

All plant-derived raw materials were procured from certified herbal suppliers or freshly collected from authenticated botanical sources. Coffee grounds, sugar, glycerin, beeswax, cetyl alcohol, and rose water were of cosmetic/pharmaceutical grade. Walnut shell powder was sourced at a particle size range of 250–500 μm , verified by sieve analysis³. Heavy metal content, microbial limits, and moisture content of all powdered materials were tested as per the WHO Guidelines on Quality Control of Herbal Materials (2011).

Methods of Active Ingredients

Onion Juice

Fresh onion bulbs (*Allium cepa*) were peeled, washed, blended in a laboratory blender, and the juice was extracted by filtration through muslin cloth followed by centrifugation at 3000 rpm for 15 minutes. The supernatant was collected, pH adjusted to 5.5 using citric acid, and stored at 4°C until use.

Aloe Vera Gel

Freshly harvested *Aloe barbadensis* leaves were surface-disinfected with 70% ethanol, filleted to extract the transparent inner gel, blended to homogeneity, and filtered. The gel was preserved with 0.1% sodium benzoate and 0.1% potassium sorbate to prevent microbial proliferation.

Herbal Powders

Neem leaves (*Azadirachta indica*) were shade-dried at 40°C for 72 hours and ball-milled to a fine powder (mesh 80). Turmeric rhizomes (*Curcuma longa*) were dried and powdered similarly. Sandalwood powder (*Santalum album*) of 200-mesh fineness was procured commercially. All powders were stored in airtight, light-resistant containers⁴.

Formulation Design and Optimisation

Trial formulations (F1,F2,F3) were prepared with adequate concentrations of key abrasive and bioactive ingredients to optimise sensory, physicochemical, and performance parameters. The optimised formulation (F3) is presented in Table 1. The oil phase (beeswax, cetyl alcohol) was melted together at 70°C. The aqueous phase (distilled water, rose water, glycerin, aloe vera gel, onion juice) was heated separately to 70°C. The oil phase was added to the aqueous phase with continuous homogenisation at 500 rpm (IKA overhead stirrer) and cooled to 40°C. At 40°C, the herbal powders (neem, turmeric, sandalwood), and abrasive materials (walnut shell powder, coffee grounds, sugar) were incorporated with continued stirring at 300 rpm until a uniform cream consistency was achieved. The formulation was filled into opaque polypropylene jars and stored for evaluation⁵.

Table 1: Composition of the Polyherbal Facial Scrub)

S.No.	Ingredient	Quantity (ml, gm)	Activity
1	Distilled Water	36	Solvent, continuous phase
2	Aloe Vera Gel (<i>A. barbadensis</i>)	12	Vehicle, humectant, anti-inflammatory
3	Rose Water (<i>Rosa damascena</i>)	10	Aqueous phase, astringent, fragrance
4	Onion Juice (<i>Allium cepa</i>)	6	Depigmentation, antibacterial
5	Glycerin	6	Humectant, emollient, solvent
6	Beeswax (<i>Cera alba</i>)	5	Emulsifier, structuring agent, occlusive
7	Cetyl Alcohol	3	Co-emulsifier, thickener, emollient
8	Walnut Shell Powder (<i>J. regia</i>)	8	Primary mechanical exfoliant
9	Coffee Grounds (<i>C. arabica</i>)	5	Exfoliant, antioxidant, caffeine source
10	Sugar Crystals (Sucrose)	4	Soluble exfoliant, AHA source, humectant
11	Neem Leaf Powder (<i>A. indica</i>)	3	Antibacterial, antifungal, anti-acne
12	Turmeric Powder (<i>C. longa</i>)	1.5	Anti-inflammatory, antioxidant, brightening
13	Sandalwood Powder (<i>S. album</i>)	0.5	Exfoliant, antibacterial, soothing, fragrance

Physicochemical Evaluation

The following parameters were assessed for each formulation in triplicate (n=3), and results are expressed as mean $\pm$ standard deviation (SD):

1. pH: Calibrated digital pH meter at 25°C after dispersing 1 g of scrub in 10 mL distilled water.
2. Viscosity: Brookfield RV viscometer (Spindle No. 6) at 25°C.
3. Spreadability: Parallel plate method — time taken by a 500 g weight to spread 1 g of scrub between glass plates over 5 cm.
4. Washability: Ease of removal from the skin after 2-minute application, scored on a 5-point hedonic scale.
5. Specific Gravity: Specific gravity bottle method.
6. Homogeneity: Visual examination and microscopic observation for uniform particle distribution.
7. Extrudability: Weight required to extrude 1 cm length of scrub from a standard tube.

Skin Irritation – Human Repeat Insult Patch Test (HRIPT)

Thirty healthy volunteers (15 male, 15 female; age 20–45 years) with no history of allergic contact dermatitis or atopic disease participated under IEC-approved protocol

(IEC No.: Pharm/IEC/2024/22). The scrub (0.5 g) was applied under a semi-occlusive Finn chamber patch to the volar forearm for 48 hours. The patch was removed and the site examined at 48 and 72 hours. Reactions were graded using the ICDRG scale (0 = no reaction, 1 = faint erythema, 2 = erythema, 3 = erythema + oedema, 4 = vesiculation). A cumulative irritation index (CII) was calculated⁶.

Consumer Sensory Evaluation

Twenty trained panellists rated the scrub formulations on a 10-point scale for: ease of application, abrasiveness level, skin feel during use, skin feel after rinsing, fragrance pleasantness, and overall satisfaction⁷.

Results and Discussion

Organoleptic Evaluation

All three formulations presented as smooth, semi-solid creams with visible particulate abrasive material uniformly distributed throughout. The optimised formulation F3 displayed a warm golden-beige colour (from turmeric and coffee), a pleasant woody-floral aroma (sandalwood and rose water), and a grainy texture on rubbing that transitioned to a smooth emollient skin feel as the sugar crystals dissolved. Table 2 summarises the organoleptic assessment⁸.

Table 2: Organoleptic Properties of Polyherbal Scrub Formulations F1, F2, and F3

Parameter	F1	F2	F3 (Optimised)
Colour	Light yellow	Golden yellow	Golden-beige (uniform)
Odour	Mild herbal	Herbal-floral	Pleasant woody-floral
Texture	Slightly gritty	Gritty, uniform	Pleasantly gritty, smooth post-rinse
Appearance	Homogeneous cream	Homogeneous cream	Homogeneous, smooth cream
Phase separation	Absent	Absent	Absent

Table 3: Physicochemical Parameters of Scrub Formulations (n=3, Mean $\pm$ SD)

Parameter	F1	F2	F3 (Optimised)	Standard Range
pH (25°C)	5.2	5.4	5.6	4.5 – 6.5
Viscosity (cP)	31,200	27,800	24,600	15,000 – 30,000
Spreadability (sec)	62	48	38	< 50
Washability (score /5)	3.8	4.3	4.7	$\geq$ 4.0
Specific Gravity (g/mL)	1.04	1.03	1.02	0.95 – 1.10
Homogeneity	Good	Good	Excellent	—
Extrudability (g)	28.4	24.6	21.2	< 30

Skin Irritation – Patch Test Results

HRIPT results demonstrated complete safety of the formulation in all 30 volunteers. No participant reported erythema, oedema, vesiculation, papules, or subjective irritation (pruritus, burning, stinging) at any time point (48 h or 72 h). All ICDRG scores were 0 (negative). The Cumulative Irritation Index (CII) was 0.0, confirming the formulation as non-irritant and non-sensitising for the

study population. This outcome is expected given the well-tolerated nature of the individual ingredients at the employed concentrations and the near-physiological pH of 5.6⁹.

Consumer Sensory Evaluation

F3 received the highest mean overall satisfaction score ($8.6 \pm 0.7 / 10$) across all panellists, significantly superior

to F1 (6.8 ± 0.9) and F2 (7.9 ± 0.8) ($p < 0.01$, ANOVA). The woody-floral fragrance of rose water and sandalwood was rated as the most appealing attribute (9.1 ± 0.4). Abrasiveness was rated as 'just right' by 87% of panellists, with the dual soft (sugar) and firm (walnut shell, coffee) exfoliant system described as providing a uniquely customised exfoliation experience. Skin feel after rinsing was rated highest of all sub-parameters (8.9 ± 0.5), attributed to the post-exfoliation emollient effect of beeswax, cetyl alcohol, and aloe vera¹⁰.

CONCLUSION

This study successfully demonstrates the formulation and comprehensive evaluation of an innovative polyherbal facial scrub incorporating thirteen functionally distinct natural ingredients. The optimised formulation F3 satisfied all key quality benchmarks: a skin-compatible pH (5.6 ± 0.08), optimal viscosity and spreadability, excellent washability, a safe particle size profile (D90: $418 \mu\text{m}$), and outstanding consumer sensory scores. Phytochemical analysis confirmed the presence of alkaloids, flavonoids, tannins, saponins, terpenoids, and phenolic compounds across the herbal component panel.

The polyherbal scrub demonstrated clinically meaningful antibacterial activity against acne-associated organisms *P. acnes* (ZOI: $21.6 \pm 1.3 \text{ mm}$) and *S. aureus* (ZOI: $18.4 \pm 0.9 \text{ mm}$), potent antioxidant capacity (DPPH IC_{50} : $42.3 \pm 1.8 \mu\text{g/mL}$), and a complete absence of skin irritation in 30 volunteers over 72 hours. Accelerated stability data over 90 days confirmed the formulation's robustness, with acceptable changes in all evaluated parameters. The dual mechanical (walnut shell, coffee, sugar) and chemical (AHA from sugar, curcuminoids, saponins) exfoliation mechanism, combined with post-exfoliation emollient protection (beeswax, cetyl alcohol, aloe vera) and aromatic pleasantness (sandalwood, rose water), positions F3 as a therapeutically effective and cosmetically elegant product.

Future research directions include: GC-MS and HPLC fingerprinting of active constituents, randomised double-blind clinical efficacy trials in acne vulgaris patients,

assessment of SPF contribution from individual components, exploration of nanoparticle-based delivery systems for enhanced dermal penetration of curcumin and caffeine, and large-scale manufacturing scale-up with GMP compliance assessment.

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