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REVIEW OF HERBAL HANDWASH CONTAINING NEEM EXTRACT

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ABSTRACT

Hand hygiene constitutes the most fundamental measure to break the transmission pathways of pathogenic microorganisms and minimize the incidence of community and healthcare-associated infectious outbreaks [1, 2]. Although modern chemical hand cleansers show significant microbicidal potency, their chronic application frequently causes dermatological issues including dry skin, severe contact irritation, epidermal cracking, and a shift in localized microflora patterns [7, 15]. Furthermore, the persistent overuse of synthetic antimicrobial compounds fuels the selection pressure driving antibiotic mutation pathways [19]. To mitigate these risks, topical formulation research focuses heavily on plant-derived alternatives [9, 13]. This review systematically evaluates liquid hand hygiene washes containing neem (*Azadirachta indica*) extract as the primary functional component [2, 20]. We analyze the extraction parameters, pharmaceutical compounding profiles, and comparative quality control data—including pH rheology, foam height indices, and physical stability attributes [9, 24]. Additionally, the in-vitro zone of inhibition studies against common cutaneous isolates such as *Staphylococcus aureus* and *Escherichia coli* are evaluated [11, 15], establishing a reliable, non-toxic, and reproducible framework for natural hand sanitation products.

Keywords**:** Review, Herbal Handwash, Neem Extract, Azadirachta indica, Compounding Standards, Evaluation.

INTRODUCTION

The practice of maintaining personal hand sanitation remains the most critical barrier against the mechanical spread of pathogenic micro-entities [2, 3]. Historically, the causal link between manual hygiene gaps and systemic disease propagation was recognized by clinical pioneers like Semmelweis and Holmes during the nineteenth century [21, 22]. Their initial empirical discoveries gained substantial validation following the formalization of modern germ theories by Pasteur and Lister [22], which positioned manual vectors as primary pathways for cross-infection [23]. In contemporary healthcare and household settings, public health agencies enforce rigorous rubbing regimens across fingers, wrists, and subungual spaces to disrupt viral and bacterial

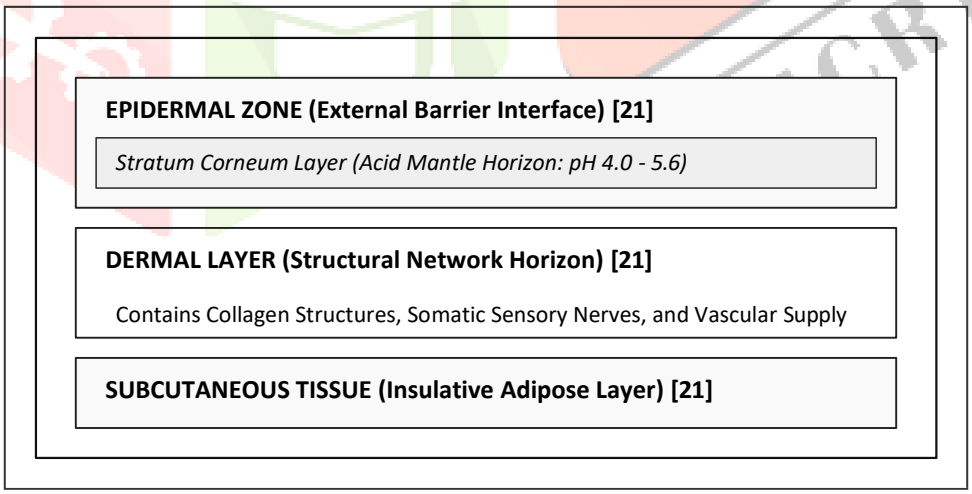
transmission chains [16, 17].

Traditional consumer networks rely extensively on synthetic hand washing formulas that incorporate chemical antimicrobial ingredients, such as chlorhexidine gluconate, triclosan, or heavy-metal compounds [20]. While these agents exhibit rapid, high-potency microbicidal destruction, their chronic, repetitive application is severely limited by multi-systemic drawbacks [21]. Synthetics extensively denature the lipid matrix of the stratum corneum, disrupting the normal homeostatic barrier function of the skin [7]. This pathologically results in excessive transepidermal water loss (TEWL), causing chronic dryness, painful skin fissures, pruritus, erythema, and severe contact dermatitis [15, 21]. Furthermore, aggressive surfactant matrices alter the protective, acidic microenvironment of the skin, destroying the beneficial resident microflora and predisposing the hands to opportunistic pathogenic colonization [19]. These challenges highlight the need for bio- compatible, sustainable alternatives derived from natural sources, with neem extract emerging as a leading active component due to its long history of safe use and high therapeutic efficiency [4, 21].

CUTANEOUS PHYSIOLOGY AND BARRIER HOMEOSTASIS

To logically design an effective topical cleansing agent, the architectural configuration of the target biological interface must be considered [1]. The human integumentary system is organized into three distinct layers: the stratified epidermis, the intermediate vascularized dermis, and the deep subcutaneous adipose matrix [21]. Each structural block contributes directly to manual defense and interacts with applied topical treatments [21].

Figure 1: Architectural diagram of the cutaneous barrier highlighting the outer epidermal acid mantle



interface [21].

The outermost stratum corneum represents the primary rate-limiting defense structure, consisting of non-viable keratinocytes embedded within an organized lipid lamellar matrix [21]. This superficial horizon is shielded by a thin hydro-lipid layer known as the acid mantle, which maintains a physiological pH range between 4.0 and 5.6 [4, 21]. This acidity provides an essential protective function, operating as an endogenous bacteriostatic buffer that naturally limits pathogenic colonization while optimizing the enzymatic pathways required for skin repair [4]. When exposed to harsh synthetic surfactants with alkaline properties, the acid

mantle is stripped away, predisposing the skin to dryness and infection [7, 19]. Below this zone, the dermis houses a network of collagen fibers and somatic nerve structures that register external chemical and mechanical stimuli [21]. To minimize irritancy and avoid triggering localized inflammation or pain signals, liquid hand washes must match the natural acidic microenvironment of the skin [21].

BOTANICAL PROFILE AND PHYTOCHEMICAL DYNAMICS OF NEEM

Neem, taxonomically known as *Azadirachta indica* A. Juss. and belonging to the family Meliaceae, is a robust tree native to tropical regions of Asia and Africa [4, 21]. Macroscopically, it features alternate, imparipinnate leaves with heavily serrated margins, a dark green hue, and a characteristic bitter taste [4]. The plant material contains a complex profile of bioactive tetranortriterpenoids, limonoids, and polyphenolic elements that drive its medicinal properties [4, 21].

The primary chemical active constituents isolated from the leaf matrix include nimbidin, azadirachtin, nimbin, nimbolinin, nimbidol, and sodium nimbinate, alongside valuable flavonol glycosides like quercetin and kaempferol [4]. Biochemically, nimbidin and azadirachtin exert strong antimicrobial actions by destabilizing bacterial cytoplasmic membrane structures, inducing localized cell wall lysis, and inhibiting essential cellular replication pathways [4, 21]. Crucially, these secondary metabolites demonstrate high potency against a broad spectrum of microbial targets without inducing mutation-driven drug resistance [19]. To create well-rounded polyherbal hand washes, neem extract is often formulated alongside supplementary botanicals, such as *Aloe vera* gel [20, 21] for humectant barrier soothing, Tulsi (*Ocimum sanctum*) [15, 21] for volatile eugenol-mediated purification, and Reetha (*Sapindus mukorossi*) [20] for natural saponin foam generation.

METHODOLOGICAL EXTRACTION AND PREPARATION PROTOCOLS

The formulation of a stable, high-potency liquid hand hygiene preparation requires a highly reproducible, standard operating extraction framework [14]. Fresh leaves of *Azadirachta indica* are collected, isolated from contaminants, and shade-dried at a stable room temperature of 25°C for 15 days [2, 20]. Thermal oven desiccation must be avoided, as temperatures above 40°C cause rapid degradation of active principles and volatile oil components [20]. After drying, the leaves are ground into a fine powder and passed through a mesh sieve to ensure uniform particle sizes [2, 21].

A cold maceration technique is used to extract the bioactive compounds [2, 20]. Precisely 25 grams of the processed powder is placed in a vessel containing 100 mL of absolute methanol or an ethanolic solvent system composed of 9 parts ethanol and 1 part water [2, 15]. The vessel is sealed with foil to prevent solvent evaporation and atmospheric oxidation, then held at room temperature for 3 to 5 days with periodic mechanical stirring [2, 20]. After filtration through a fine filter unit to remove particulate matter [2, 21], the filtrate is transferred to a rotary vacuum evaporator and concentrated under reduced pressure at 40°C [2]. The remaining dark green resinous extract is placed in a vacuum desiccator containing silica gel to cool and remove moisture [2, 20], yielding a stable phytochemical matrix ready for formulation compounding [2, 21].

PHARMACEUTICAL FORMULATION ENGINEERING

Compounding a liquid herbal wash requires the careful integration of active plant extracts with specialized pharmaceutical excipients to ensure consistency, elegance, and durability [1, 21]. The structured formulation components, derived from standard compounding designs, are detailed in Table 1 [2, 15, 21].

The manufacturing process follows a strict phase sequence to prevent polymer aggregation and ensure absolute homogeneity [21]. The gelling agent (Carbopol) is first dispersed in 15 mL of distilled water and left overnight to fully hydrate [21]. Separately, the calculated volume of methanolic neem leaf extract is mixed with natural Reetha saponins and heated mildly to 50°C [20]. The accessory surfactant (SLS) and glycerin are mixed into a secondary aqueous vehicle under low-speed mechanical stirring to prevent air entrapment [15, 21]. The concentrated active plant extract phase is then added smoothly to this polymer system [21]. Methyl paraben is dissolved in a minimal amount of warm water and added to provide a robust defense against contamination [21]. Finally, triethanolamine or a 40% NaOH solution is introduced dropwise [2, 21]. As the system reaches neutrality, the Carbopol chains rapidly ionize, expanding the polymer network into a thick, uniform gel matrix [21]. Natural lemon juice or rose oil is added to complete the aroma [2], and the final volume is adjusted to 100 mL using purified water [2, 15, 21].

SYSTEMATIC QUALITY EVALUATION AND CONTROL PARAMETERS

To qualify for clinical applications, every prepared batch of neem-based handwash must undergo strict multi-parametric physical and chemical quality screening to guarantee absolute safety and batch-to-batch consistency [9, 14, 21].

Organoleptic Properties and Homogeneity

The product baseline is evaluated through thorough organoleptic inspection [9, 21]. The gel is checked visually against alternating backgrounds to confirm a stable, translucent green color derived naturally from the plant leaves [2, 15]. The aroma is evaluated by an individual panel study of healthy volunteers [2]; it must present a clean, pleasant scent that effectively masks the strong bitter odor of crude neem [2, 21]. Texture is assessed by manual touch between the fingertips [21], confirming a completely smooth, non-gritty profile that shows all botanical matter has been successfully filtered [21]. Homogeneity is monitored by keeping samples in glass containers for 72 hours to verify that no physical phase separation, localized precipitation, or product thinning occurs [2, 21].

Rheological Analytics: pH and Viscosity

The chemical pH of the formulation directly dictates skin compatibility and safety [1, 19]. A 1.0-gram sample of the liquid gel is thoroughly dissolved in 100 mL of neutral distilled water to prepare a 1% w/v dispersion, which is measured using a calibrated digital pH meter [2, 21]. Tested batches must maintain a pH range between 5.1 and 6.5 [2, 19, 20], mirroring the skin's natural acidic mantle and avoiding epidermal barrier breakdown [1, 21]. Viscosity, which controls fluid flow and manual handling, is evaluated using a digital Brookfield viscometer at 25°C [2, 15]. Formulations show an optimized viscosity distribution between 28 cP and 62 cP [2, 15, 19], allowing clean dispensing through pump mechanisms while providing adequate manual spreadability [15].

Performance Dynamics: Foam Metrics

Foaming capacity is a critical driver of user compliance and cleansing efficacy [21]. Foam height is quantified by placing 1.0 gram of the handwash in 50 mL of water, transferring the mix to a 500 mL graduated cylinder, and making up the volume to 100 mL [2, 20]. The cylinder is inverted 25 times within 30 seconds and placed on a flat surface [2, 20]. The initial height of the foam layer is recorded, with optimized formulas producing a robust foam height between 3.3 cm and 7.0 cm or 340 mL to 360 mL in large-scale tests [2, 15]. Foam retention is monitored by measuring remaining volumes at 1-minute intervals across a 5-minute window [2, 15]; the bubble structure must remain highly stable for a minimum of 4 to 5 minutes to support proper hand washing intervals [2, 20].

IN-VITRO MICROBIOLOGICAL EFFICACY

To validate the antiseptic performance of the formulation, samples are subjected to in-vitro microbiological evaluation using the standard agar well diffusion protocol against standard bacterial isolates [15, 19]: Gram- positive *Staphylococcus aureus* and *Bacillus subtilis*, and Gram-negative *Escherichia coli* and *Pseudomonas aeruginosa* [15, 19]. Sterile Nutrient Agar or Soybean Casein Digest Agar (SCDA) media is autoclaved at 121°C and poured into sterile Petri plates under laminar airflow hoods to solidify [15, 20]. The target pathogens are adjusted to a 0.5 MacFarland standard and spread uniformly across the agar surface to establish a dense bacterial lawn [15, 20].

Table 1: Comparative in-vitro antibacterial zone of inhibition data (cm) for neem formulations [15, 19].

TARGET MICROORGANISM BACTERIAL STRAIN	**CUTANEOUS PATHOLOGY CLASS**	**PURE NEEM BASE (F-1) [19]**	**NEEM + LEMON BASE (F-2) [19]**	**POSITIVE STANDARD CONTROL (AMOXICILLIN) [19]**
Staphylococcus aureus	Gram-Positive Isolate	3.8 cm	4.3 cm	2.7 cm
Bacillus subtilis	Gram-Positive Isolate	3.4 cm	3.8 cm	1.4 cm
Escherichia coli	Gram-Negative Isolate	3.3 cm	3.8 cm	1.8 cm
Pseudomonas aeruginosa	Gram-Negative Isolate	3.6 cm	4.2 cm	2.3 cm

Using a sterile punch, uniform 6 mm wells are formed in the agar [15, 20]. The wells are filled with specific volumes of the experimental neem handwash, a negative vehicle control, and a positive standard antibiotic control [15, 20]. The plates are incubated at 37°C for 24 hours [15, 20]. Following incubation, the clear, circular zones of growth inhibition surrounding the wells are measured using a digital caliper [15, 19]. As shown in Table 2, the neem-based formulations exhibit potent antibacterial activity, frequently outperforming standard antibiotic metrics [19]. This confirms that the active tetranortriterpenoids from neem efficiently disrupt bacterial cellular walls [15], leading to rapid cell death across both Gram-positive and Gram-negative lines without promoting resistance mutation pathways [19].

STABILITY PROFILES AND DERMATOLOGICAL COMPATIBILITY

To verify long-term quality over an extended shelf life, finished handwash batches are placed in environmental chambers for accelerated stability testing in accordance with international guidelines [14]. Samples are stored under varying thermal profiles: 5°C, 25°C, 37°C, and an accelerated level of 45°C with 75% relative humidity for a prolonged period [2, 15, 21]. The gel demonstrates high stability, showing no signs of color loss, syneresis, fluid thinning, or phase separation [2, 15, 21]. Viscosity and pH indices remain constant within their established parameters [15], confirming that the cross-linked polymer network effectively treats the complex botanical extract without breaking down [21].

Dermatological safety is verified through a standard human skin patch test and irritancy analysis [9, 21]. A small, uniform sample of the gel is applied to a 1 cm^2 area on the inner forearm of human volunteers, protected with a non-reactive patch, and monitored closely for 30 to 60 minutes [21]. After removing the patch and washing the site, the skin is assessed using a sensory grading scale for signs of erythema, edema, localized pruritus, or skin irritation [21]. The formulation records an irritation index score of zero, demonstrating excellent biological safety [15, 21]. This absolute lack of irritation confirms that combining natural Reetha saponins with soothing *Aloe vera* provides a highly effective, bio-compatible cleansing action that treats cutaneous physiology [20, 21], making it completely safe for everyday hygiene applications [21].

CONCLUSION

This systematic review highlights that liquid herbal handwashes containing neem (*Azadirachta indica*) extract serve as a highly effective, safe, and ecologically sustainable alternative to conventional synthetic chemical cleansers [2, 21]. By engineering a balanced matrix that pairs active neem limonoids with natural surfactant elements and viscosity modifiers, the resulting gel delivers high microbicidal destruction against common pathogens while maintaining complete harmony with the skin's acidic microenvironment [15, 19]. The standard testing data reviewed indicates that these natural preparations meet all rigorous pharmaceutical requirements for physical homogeneity, pH rheology, foam metrics, and long-term shelf stability without causing localized cutaneous irritation or systemic toxicity [2, 21]. Advancing these natural, plant-based formulations offers a clear path toward safe public health hygiene while directly addressing the global challenge of antimicrobial resistance [19].

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