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Research Article

# FORMULATION AND EVALUATION OF POLYHERBAL HAND SANITIZER USING INDIAN MEDICINAL PLANTS

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**Abstract**

Hand hygiene remains one of the most effective preventive measures for reducing the transmission of infectious diseases in both healthcare and community settings. Human hands serve as major vectors for the spread of bacterial, viral, and fungal pathogens, making effective hand sanitization an essential public health intervention.

The present study aimed to formulate and evaluate a polyherbal hand sanitizer incorporating extracts of Neem (Azadirachta indica), Tulsi (Ocimum sanctum), Aloe vera (Aloe barbadensis), and Mint (Mentha arvensis) as active botanical ingredients. These medicinal plants were selected based on their established antimicrobial, anti-inflammatory, antioxidant, antiviral, and skin-protective properties. The herbal hand sanitizer was formulated using a hydroalcoholic base containing isopropyl alcohol, glycerin, and distilled water as excipients. The prepared formulation was evaluated for physicochemical properties, skin compatibility, and short-term stability.

The final formulation demonstrated acceptable organoleptic characteristics, including green appearance, pleasant odor, smooth texture, and acceptable consistency. Physicochemical evaluation showed a pH range of 5.5–7.0, bulk density of 0.75 g/mL, tapped density of 0.857 g/mL, and acceptable flow-related characteristics. Skin irritation testing demonstrated no visible erythema, itching, swelling, or discomfort, indicating favorable dermatological compatibility. Stability observations revealed no significant changes in color, odor, texture, or pH during the study period. The findings suggest that the developed polyherbal hand sanitizer may serve as a safe and cosmetically acceptable hygiene formulation with potential antimicrobial utility.

Keywords: Herbal hand sanitizer, polyherbal formulation, neem, tulsi, aloe vera, mint, hand hygiene, antimicrobial formulation.

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## Introduction

Hand hygiene is universally recognized as one of the most effective and economical public health interventions for preventing the transmission of infectious diseases. Human hands frequently come into contact with contaminated environmental surfaces and subsequently act as vectors for transferring pathogenic microorganisms to the mouth, nose, eyes, and other individuals. Inadequate hand hygiene contributes significantly to the spread of respiratory infections, gastrointestinal illnesses, hospital-acquired infections, and community-transmitted communicable diseases (1,3).

Traditionally, handwashing with soap and water has remained the gold standard for hand decontamination. Mechanical washing physically removes microorganisms, organic debris, and contaminants from the skin surface while surfactants facilitate cleaning. However, in many practical settings including healthcare facilities, schools, workplaces, public transportation, and travel environments, immediate access to soap and clean water may be limited. Under such circumstances, hand sanitizers provide a practical, rapid, and effective alternative for maintaining hand hygiene (4).

Alcohol-based hand sanitizers are the most commonly used commercial products because of their rapid broad-spectrum antimicrobial action. Ethanol and isopropyl alcohol exert antimicrobial effects through protein denaturation, membrane disruption, and enzyme inactivation, leading to microbial cell death (5). International guidelines recommend alcohol concentrations sufficient to ensure reliable microbial reduction.

Despite their effectiveness, repeated use of alcohol-based sanitizers may produce undesirable dermatological effects including skin dryness, irritation, dermatitis, and barrier lipid depletion, particularly in individuals with sensitive skin (2). The presence of synthetic fragrances, preservatives, and chemical additives may further contribute to hypersensitivity reactions and reduced consumer tolerability.

This has led to increasing interest in herbal hand sanitizer formulations that incorporate medicinal plant extracts with antimicrobial and skin-protective properties. Herbal products are often perceived as safer, environmentally sustainable, biodegradable, and more dermatologically compatible alternatives to synthetic products (6).

Neem (*Azadirachta indica*) is a well-established medicinal plant with potent antibacterial, antifungal, antiviral, antioxidant, and anti-inflammatory properties. Its therapeutic activity is attributed to bioactive compounds including azadirachtin, nimbin, nimbidin, flavonoids, tannins, and essential oils (7,8). Tulsi (*Ocimum sanctum*) is recognized for its antimicrobial, antiviral, antioxidant, and immunomodulatory properties, largely due to phytochemicals such as eugenol, ursolic acid, rosmarinic acid, and flavonoids (9).

Aloe vera (*Aloe barbadensis*) contributes moisturizing, soothing, wound-healing, antimicrobial, and anti-inflammatory benefits, making it particularly useful in counteracting alcohol-induced skin dryness (10). Mint (*Mentha arvensis*) contributes cooling, refreshing, antimicrobial, and aromatic properties through constituents such as menthol and essential oils (11).

Combining these medicinal plants in a polyherbal formulation may provide synergistic antimicrobial effects while improving skin compatibility and cosmetic acceptability. The present study was therefore undertaken to formulate and evaluate a polyherbal hand sanitizer using selected Indian medicinal plants.

## Materials and Methods

The present study involved the formulation and evaluation of a polyherbal hand sanitizer using medicinal plant extracts selected for their antimicrobial and dermatological properties. Fresh leaves of neem (*Azadirachta indica*), tulsi (*Ocimum sanctum*), mint (*Mentha arvensis*), and aloe vera (*Aloe barbadensis*) were collected from local sources and authenticated prior to use. Plant materials were thoroughly washed with distilled water to remove dust and foreign contaminants, followed by shade drying and controlled oven drying to eliminate residual moisture.

Neem, tulsi, and mint leaves were separately pulverized into fine powder using a mechanical grinder. Ethanolic extraction was performed by mixing 10 g of each powdered plant material with appropriate ethanol volumes followed by heating at 80–100°C for 5–10 minutes in a controlled water bath. The mixtures were filtered using standard filtration methods to obtain clear herbal extracts.

Aloe vera extract was prepared by collecting fresh leaves, thoroughly washing them, carefully removing the outer rind, and separating the internal transparent gel. The gel was blended to obtain a homogeneous liquid and filtered to remove fibrous material before storage under refrigerated conditions.

The herbal hand sanitizer formulation was prepared according to the thesis formulation composition. For a final 30 mL preparation, neem extract (3.5 mL), tulsi extract (2.5 mL), aloe vera extract (2.5 mL), mint

extract (4.5 mL), isopropyl alcohol (12.5 mL), glycerin (4 mL), and distilled water sufficient to volume were used.

The formulation was prepared by first transferring the measured quantity of isopropyl alcohol into a sterile beaker. Herbal extracts of neem, tulsi, and mint were added gradually with continuous stirring to ensure uniform mixing. Aloe vera extract and glycerin were subsequently incorporated to improve moisturizing characteristics and formulation stability. The mixture was homogenized using mechanical stirring until a uniform preparation was obtained. The pH was adjusted within the skin-compatible range using suitable adjustment procedures, and distilled water was added to achieve the final desired volume. The final formulation was filtered and transferred into sterile airtight containers for evaluation.

Evaluation of the prepared formulation included organoleptic assessment, physicochemical testing, skin compatibility assessment, and stability studies. Organoleptic evaluation included visual and sensory examination of appearance, odor, texture, consistency, and overall cosmetic acceptability. Physicochemical evaluation included pH determination, bulk density, tapped density, and particle-related flow characteristics as reported in the thesis dataset.

Skin irritation testing was conducted through topical application of a small quantity of the sanitizer to the forearm of healthy volunteers, followed by observation for visible erythema, itching, burning sensation, swelling, rash formation, or discomfort over 24 hours.

Stability studies involved storing the prepared formulation under standard observation conditions and monitoring for physical changes including color alteration, odor changes, precipitation, phase separation, texture modification, and pH variation.

**Results**

The formulated polyherbal hand sanitizer was successfully prepared and evaluated for physicochemical suitability, dermatological compatibility, and short-term formulation stability. The developed formulation demonstrated acceptable characteristics consistent with the intended application as a topical hand hygiene preparation.

Organoleptic evaluation revealed that the prepared hand sanitizer exhibited a **green appearance**, attributable to the incorporation of the selected herbal extracts, particularly neem, tulsi, and mint. The formulation possessed a **pleasant herbal odor**, which improved sensory acceptability and user convenience. The texture was smooth and homogeneous, indicating successful blending of the hydroalcoholic and herbal components without visible precipitation or phase separation.

The pH of the formulation was found to be within the range of **5.5 to 7.0**, indicating acceptable compatibility with the physiological pH of human skin. Maintenance of pH within this range is important to reduce the likelihood of skin irritation and preserve epidermal barrier integrity during repeated application.

Physicochemical evaluation demonstrated a **bulk density of 0.75 g/mL** and a **tapped density of 0.857 g/mL**. These values indicate acceptable formulation consistency and packaging suitability. The thesis also reported a particle-related parameter value of **24.3**, suggesting acceptable formulation uniformity, although interpretation is limited by methodological reporting inconsistencies in the original dataset.

Skin compatibility assessment demonstrated favorable tolerability. No visible erythema, itching, rash, burning sensation, swelling, or discomfort was observed following topical application during the monitoring period, indicating acceptable short-term dermatological safety.

Stability observations showed no significant physical changes in color, odor, consistency, or pH during the study period, suggesting acceptable short-term stability of the prepared formulation under standard storage conditions.

Overall, the developed formulation demonstrated acceptable cosmetic and practical characteristics suitable for further evaluation as a herbal hand hygiene product.

**Discussion**

The present study successfully demonstrated the formulation and preliminary evaluation of a polyherbal hand sanitizer incorporating neem, tulsi, aloe vera, and mint in a hydroalcoholic base. The findings support the growing interest in integrating medicinal plant extracts into hygiene formulations to enhance antimicrobial potential while improving dermatological compatibility (1,2).

Hand hygiene remains a cornerstone of infection prevention in both healthcare and community settings. Effective sanitization reduces transmission of pathogenic microorganisms responsible for respiratory, gastrointestinal, and contact-transmitted infectious diseases (3). Although alcohol-based sanitizers are highly effective and remain internationally recommended, their frequent use may contribute to skin dryness, irritation, and barrier dysfunction, particularly with repeated exposure (5).

The incorporation of skin-protective herbal ingredients therefore represents a rational formulation strategy.

The organoleptic characteristics of the present formulation were favorable. Cosmetic acceptability plays a significant role in user compliance, especially for hygiene products intended for repeated daily use. The pleasant herbal odor and visually acceptable appearance may positively influence consumer preference compared with formulations with harsh alcohol odors or poor aesthetic properties.

The measured pH range of 5.5–7.0 suggests reasonable dermatological compatibility. Human skin typically maintains a mildly acidic surface environment that supports antimicrobial defense, enzymatic regulation, and barrier integrity (12). Formulations with markedly inappropriate pH may increase the risk of irritation or barrier compromise. The observed pH range suggests suitability for topical hand application.

The inclusion of neem provides strong pharmacological justification due to its broad-spectrum antimicrobial and anti-inflammatory properties. Neem contains bioactive compounds such as azadirachtin, nimbidin, nimbin, tannins, and flavonoids, which demonstrate antibacterial, antifungal, antiviral, and antioxidant activity (7,8). These properties support its role in hygiene formulations.

Tulsi similarly contributes antimicrobial and antiviral activity through phytoconstituents including eugenol, rosmarinic acid, and flavonoids (9). Its established traditional use in infection prevention supports its inclusion in the polyherbal combination.

Aloe vera contributes an important dermatological balancing effect by providing hydration, soothing activity, and anti-inflammatory support (10). This is particularly relevant in alcohol-containing formulations, where aloe vera may help mitigate dryness and irritation associated with repeated use.

Mint enhances the formulation through its refreshing sensory effect, antimicrobial contribution, and improved cosmetic acceptability. Menthol-containing herbal preparations are widely recognized for cooling and deodorizing benefits (11).

The short-term stability observations are encouraging, indicating acceptable physical compatibility among the herbal extracts, hydroalcoholic vehicle, and humectant components. Stability is particularly important in herbal formulations, where phytochemical interactions may lead to precipitation, discoloration, odor degradation, or microbial instability if not properly formulated (13).

However, an important scientific limitation must be acknowledged. While the formulation was conceptually designed as a hand sanitizer, the thesis methodology includes certain evaluation parameters more typical of dry powder systems, suggesting inconsistency in reporting methodology. Consequently, interpretation of some physicochemical values should be approached cautiously. Nevertheless, the core findings support the feasibility of the polyherbal sanitizer concept.

The present findings align with previous investigations supporting the incorporation of medicinal plant extracts into hand hygiene products to improve antimicrobial functionality and dermatological tolerability (14,15).

**Limitations of the Study**

Despite the promising findings of the present investigation, several limitations should be acknowledged. The study primarily involved preliminary formulation development and basic physicochemical evaluation without comprehensive microbiological efficacy testing against clinically relevant bacterial, viral, or fungal pathogens. As a hand sanitizer, antimicrobial performance represents the most critical functional endpoint, and this was not quantitatively validated using standard microbiological methods such as zone of inhibition testing, microbial reduction assays, or time-kill studies. The stability assessment was limited to short-term observational monitoring and did not include accelerated stability testing under controlled environmental stress conditions. Controlled dermatological testing involving larger volunteer populations was not conducted, limiting broader conclusions regarding long-term skin safety and tolerability. Certain methodological inconsistencies in the original thesis dataset, particularly regarding evaluation terminology, restrict precise interpretation of some reported physicochemical parameters. Future studies should incorporate standardized antimicrobial efficacy testing, extended stability assessment, rigorous dermatological safety evaluation, and validated formulation characterization to strengthen scientific credibility and potential product development applicability.

**Conclusion**

The present study successfully formulated and preliminarily evaluated a polyherbal hand sanitizer incorporating neem, tulsi, aloe vera, and mint using a hydroalcoholic formulation approach. The developed sanitizer demonstrated acceptable organoleptic properties, suitable pH, favorable dermatological compatibility, and satisfactory short-term physical stability.

The selected medicinal plants provide a rational synergistic formulation strategy by combining antimicrobial, antiviral, anti-inflammatory, moisturizing, and sensory benefits. The inclusion of aloe vera and glycerin may offer improved skin tolerability compared with conventional alcohol-only formulations.

Although microbiological efficacy remains to be experimentally validated, the findings support the feasibility of developing herbal hand hygiene products as cosmetically acceptable and potentially beneficial alternatives or adjuncts to conventional sanitizers.

Further investigations involving standardized antimicrobial validation, long-term stability testing, and larger dermatological safety studies are required before broader practical or commercial application.

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