



**INTERNATIONAL JOURNAL OF
PHARMACEUTICAL SCIENCES**
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: <https://www.ijpsjournal.com>



Research Article

Development of Alcohol-Free Herbal Sanitizer Using Silver Nanoparticles: A Sustainable Approach to Hand Hygiene

Prassanna Bhadange, Vinayak Bhavsar, Vaishnavi Bohade, Nikhil Kadam*, Yash Bachhav, Ritesh Karmarkar

Department of Pharmaceutics, MGV's S. P. H. College of Pharmacy, Malegaon, Dist. Nashik, Maharashtra, India.

ARTICLE INFO

Published: 03 Mar. 2025

Keywords:

Alcohol-free sanitizer, Silver nanoparticles, Herbal extracts, Antimicrobial activity, Hand hygiene

DOI:

10.5281/zenodo.14958915

ABSTRACT

Background: Hand hygiene is crucial for preventing infectious diseases, but conventional alcohol-based sanitizers cause skin dryness, irritation, and flammability concerns. Alcohol-free herbal sanitizers with silver nanoparticles (AgNPs) and plant extracts offer an alternative with antimicrobial properties, skin-friendliness, and sustainability. **Method:** An alcohol-free herbal sanitizer was formulated using AgNPs (50 ppm solution) and plant extracts including Aloe vera, Neem, Tea Tree Oil, Eucalyptus Oil, and Lemon Extract. Silver nanoparticles were synthesized via chemical reduction using sodium citrate and characterized using UV-visible spectroscopy, TEM, and DLS. The formulation was prepared by integrating herbal extracts and AgNPs into a thickened gel base with xanthan gum, glycerin, and Vitamin E. The antimicrobial activity was evaluated using the agar diffusion method and Minimum Inhibitory Concentration (MIC) determination. Stability tests were conducted at 25°C and 40°C over 30 days to assess physical consistency and microbial contamination. **Results:** The sanitizer exhibited a clear, gel-like consistency with no separation over 30 days. It demonstrated strong antibacterial activity, forming inhibition zones of 18 mm for *E. coli* and 20 mm for *S. aureus*. The MIC values were 5% for *E. coli* and 4% for *S. aureus*, confirming efficacy at low concentrations. The formulation maintained a skin-friendly pH of 5.5, ensuring safety for frequent use. Stability testing showed no microbial contamination or physical degradation. **Conclusion:** The alcohol-free herbal sanitizer with AgNPs and plant extracts is an effective, stable, and safe alternative to conventional sanitizers. It provides potent antimicrobial protection without skin irritation, making it a sustainable solution for frequent hand hygiene. Future research should explore its efficacy against a broader range of microorganisms and its potential for commercial production.

*Corresponding Author: Nikhil Kadam

Address: Department of Pharmaceutics, MGV's S. P. H. College of Pharmacy, Malegaon, Dist. Nashik, Maharashtra, India

Email ✉: nikhilkadam89@gmail.com

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.



INTRODUCTION

Hand hygiene is a crucial aspect of personal and public health, helping to prevent the spread of infectious diseases¹. Conventional alcohol-based hand sanitizers are widely used; however, they have drawbacks such as skin dryness, irritation, and flammability². As an alternative, alcohol-free herbal hand sanitizers incorporating silver nanoparticles and plant extracts have gained interest due to their antimicrobial properties, skin-friendliness, and sustainability³. Silver nanoparticles (AgNPs) have been extensively studied for their potent antimicrobial activity against bacteria, viruses, and fungi⁴. They work by disrupting microbial cell membranes, interfering with protein synthesis, and generating reactive oxygen species that lead to cell death⁵. Their incorporation in hand sanitizers enhances the efficacy of the formulation without causing skin irritation⁶. Plant-based extracts such as *Aloe vera*, Turmeric (*Curcuma longa*), Tea tree oil (*Melaleuca alternifolia*), Eucalyptus oil (*Eucalyptus globulus*), Neem (*Azadirachta indica*), and Lemon extract (*Citrus limon*) provide additional antimicrobial, anti-inflammatory, and skin-soothing benefits⁷. *Aloe vera* acts as a natural moisturizer and wound healer, reducing skin dryness often associated with sanitizers⁸. Turmeric extract is known for its antibacterial, antifungal, and anti-inflammatory properties due to the presence of curcumin⁹. Tea tree oil and eucalyptus oil are well-known for their broad-spectrum antimicrobial activity, effectively eliminating pathogens¹⁰. Neem extract possesses strong

antibacterial and antifungal effects, further enhancing the protective action of the formulation¹¹. Lemon extract contributes to the formulation by providing a refreshing fragrance and additional antimicrobial activity¹².

The alcohol-free formulation of the herbal hand sanitizer ensures that it is non-toxic, non-flammable, and suitable for frequent use, especially for individuals with sensitive skin, children, and those following religious restrictions on alcohol use¹³. Additionally, the use of natural plant-based extracts makes the formulation environmentally friendly and biodegradable, reducing the impact of chemical waste on the ecosystem¹⁴. The incorporation of silver nanoparticles into an herbal-based sanitizer offers synergistic effects, enhancing the overall antimicrobial action of the formulation¹⁵. Unlike alcohol-based sanitizers, which provide temporary microbial reduction, silver nanoparticles can offer long-lasting protection due to their sustained release and action against microorganisms¹⁶.

In summary, the development of an alcohol-free herbal hand sanitizer using silver nanoparticles and plant extracts presents a promising solution for effective hand hygiene while ensuring skin safety and environmental sustainability¹⁷. This formulation could be beneficial for hospitals, schools, workplaces, and public spaces where frequent hand sanitization is required¹⁸.

MATERIALS AND METHODS

Materials

I. Formula of Preparation.

Ingredient	Quantity for 100 ml	Purpose
Aloe Vera Extract	3 ml	Skin soothing, antimicrobial
Neem Extract	2 ml	Antibacterial, antifungal
Tea Tree Oil	1 ml	Antimicrobial, anti-inflammatory
Eucalyptus Oil	1 ml	Antiviral, antibacterial
Lemon Extract	1 ml	Antimicrobial, refreshing scent
Silver Nanoparticles (AgNPs, 50 ppm solution)	1.5 ml	Antimicrobial action
Glycerin	3 ml	Moisturizing agent
Xanthan Gum	0.7 gm	Thickening agent
Vitamin E (Natural Preservative)	0.5 ml	Antioxidant, preservative
Distilled Water	Q.S	Solvent base



II. Silver Nanoparticles (AgNPs)

- **Synthesis:** Chemical reduction was used to create silver nanoparticles. Silver nanoparticles were created by reducing a 1 mM silver nitrate solution with sodium citrate at boiling temperatures.
- **Characterization:** The following methods were used to describe the nanoparticles:
 - UV-visible spectroscopy: To verify the creation of nanoparticles, the absorption peak was recorded at 420–450 nm.
 - Using transmission electron microscopy (TEM), one may examine the size and form of particles.
 - Dynamic Light Scattering (DLS): To guarantee stability and measure the size distribution.

Methods

I. Preparation of Alcohol-Free Herbal Sanitizer

The formulation of the alcohol-free herbal sanitizer involved the following steps:

- **Ingredients:**
- **Herbal extracts (Aloe Vera, Neem, Tea Tree Oil, Eucalyptus Oil, Lemon Extract):** 5-10% concentration depending on the antimicrobial strength of each extract.
- **Silver Nanoparticles:** 0.5-2% concentration, depending on the desired antimicrobial potency.
- **Glycerin:** 2-5% for moisturizing properties.
- **Distilled Water:** The solvent for preparing the base solution.
- **Xanthan Gum:** 0.5-1% for thickening the formulation and improving the gel-like consistency.
- **Preservatives:** A natural preservative like Vitamin E or Grapefruit Seed Extract (GSE) may be used to prevent microbial growth in the final product.

II. Formulation Procedure:

1. Preparation of Herbal Extract Base:

- a. The necessary concentrations of each herbal extract—lemon, eucalyptus, tea tree, neem, and aloe vera—were combined with distilled water. To avoid irritating the skin and guarantee uniform dispersion in the gel, oils such as eucalyptus and tea tree were combined with a carrier oil, such as coconut or olive oil.

2. Silver Nanoparticle Integration:

- a. The synthesized silver nanoparticles were incorporated into the herbal extract base. The silver nanoparticles were dispersed uniformly by stirring at a low speed to avoid aggregation.

3. Thickening Agent Addition:

- a. To make sure the mixture thickened evenly, xanthan gum was added gradually while stirring. Glycerin is added to the sanitizer to enhance its consistency and smoothness.

4. Preservative Addition:

- a. A natural preservative was added to the formulation to increase its shelf life and prevent microbial contamination.

5. Final Adjustments:

- a. Citric acid or sodium hydroxide were used to bring the formulation's pH down to about 5–6, making it safe for skin application.

6. Homogenization:

- a. The final formulation was homogenized using a mechanical stirrer or high-shear mixer for 15-20 minutes to achieve a smooth, uniform consistency.

III. Evaluation of Antimicrobial Activity

- **Agar Diffusion Method:** Applying the sanitizer to inoculated agar plates allowed for the testing of its antibacterial activity. Following a 24-hour incubation period, the zone of inhibition was assessed.
- **MIC Determination:** The Minimum Inhibitory Concentration (MIC) was identified using serial dilution to determine the lowest concentration that inhibited bacterial growth.

Stability and Shelf Life Testing

- **Thermal Stability:** The sanitizer was stored at 40°C and 25°C for 30 days to monitor its



physical properties, including texture and separation.

- **Microbial Stability:** Regular microbial testing was carried out to ensure that the

formulation remained free from contamination over time.



Fig 1. Prepared Alcohol Free Herbal Hand Sanitizer By Using Silver Nano Particles.

RESULT AND DISCUSSION

RESULT

Test	Observations/Findings
Visual and Physical Appearance	Clear, gel-like consistency with no separation over 30 days.
Antimicrobial Effectiveness	E. Coli: 18 mm inhibitory zone. S. aureus: inhibitory zone of 20 mm.
Minimum Inhibitory Concentration (MIC)	E. coli: 5% MIC. S. aureus: 4% MIC.
pH	pH of 5.5, suitable for skin application.
Stability	Stable at 25°C and 40°C for 30 days with no change in texture or appearance.
Shelf Life and Microbial Safety	No microbial contamination observed over 30 days. Effective natural preservatives used.

Proof Examples:

- **Zone of Inhibition:** Agar plate photograph displaying *S. aureus* and *E. coli* zones of inhibition.
- **MIC Testing:** Data from dilution test showing bacterial growth inhibition at specific concentrations.
- **pH Measurement:** pH reading obtained from a calibrated pH meter (5.5).

- **Microbial Testing:** Record of microbial testing results showing no contamination in the product over time.

Discussion

- With zones of inhibition of 18 mm for *E. coli* and 20 mm for *S. aureus*, the alcohol-free herbal sanitizer showed potent antibacterial qualities and was successful in preventing bacterial growth. This antibacterial activity was probably aided by the combination of plant extracts like neem and tea tree oil with

silver nanoparticles. The natural antibacterial components in the herbal ingredients amplify

the well-known broad-spectrum antimicrobial actions of silver nanoparticles.



Fig. 2 Zones of Inhibition of 18 Mm For E. Coli

- The MIC values for *S. aureus* (4%) and *E. coli* (5%) demonstrate that the sanitizer is economical while retaining potent antibacterial activity at low concentrations. With a pH of 5.5, the product is safe to apply to the skin since it balances the pH of the skin and causes the least amount of irritation.
- The product remained stable at both 25°C and 40°C for 30 days, with no changes in appearance or texture, confirming its long shelf life. The inclusion of Vitamin E as a preservative further ensured the product remained free from microbial contamination during this period.
- In conclusion, the alcohol-free herbal sanitizer with silver nanoparticles is effective, stable, and safe for use, offering a natural, skin-friendly alternative to alcohol-based sanitizers. Further research could explore its application against a broader range of microorganisms and its potential for commercial use.

CONCLUSION

Using herbal extracts and silver nanoparticles, the alcohol-free herbal sanitizer has significant antibacterial efficacy against common infections like *S. aureus* and *E. coli*. Compared to alcohol-based sanitizers, the product offers a skin-friendly and effective alternative due to its low Minimum

Inhibitory Concentration (MIC). With the potential for commercial development, this compound exhibits promise as an affordable, environmentally friendly, and skin-safe disinfectant. Future studies could examine a wider range of antibacterial activity and further refine the formulation for commercial use and large-scale manufacturing.

REFERENCES

1. World Health Organization. Hand hygiene: Why, how & when?. WHO; 2009. https://www.who.int/gpsc/5may/Hand_Hygiene_Why_How_and_When_Brochure.pdf
2. Kampf G, Löffler H, Gastmeier P. Hand hygiene for the prevention of nosocomial infections. *Dtsch Arztebl Int.* 2009;106(40):649-55.
3. Karunaratne DN, Wijesundera SA. Silver nanoparticles in herbal-based sanitizers: A novel approach to hand hygiene. *J Nanobiotechnol.* 2021;19(1):45.
4. Rai M, Yadav A, Gade A. Silver nanoparticles as a new generation of antimicrobials. *Biotechnol Adv.* 2009;27(1):76-83.
5. Kim JS, Kuk E, Yu KN, et al. Antimicrobial effects of silver nanoparticles. *Nanomedicine.* 2007;3(1):95-101.
6. Duran N, Duran M, de Jesus MB, Seabra AB, Fávaro WJ, Nakazato G. Silver nanoparticles:

- A new view on mechanistic aspects on antimicrobial activity. *Nanomedicine*. 2016;12(3):789-99.
7. Ahmad A, Wei Y, Syed F, et al. Plants as green source of silver nanoparticles and their biomedical applications. *Biotechnol Bioprocess Eng*. 2022;27(2):133-50.
 8. Surjushe A, Vasani R, Saple DG. Aloe vera: A short review. *Indian J Dermatol*. 2008;53(4):163-6.
 9. Prasad S, Aggarwal BB. Turmeric, the golden spice: From traditional medicine to modern medicine. *Adv Exp Med Biol*. 2011;595:1-25.
 10. Carson CF, Hammer KA, Riley TV. *Melaleuca alternifolia* (tea tree) oil: A review of antimicrobial and other medicinal properties. *Clin Microbiol Rev*. 2006;19(1):50-62.
 11. Subapriya R, Nagini S. Medicinal properties of neem leaves: A review. *Curr Med Chem Anticancer Agents*. 2005;5(2):149-56.
 12. Fisher K, Phillips CA. The mechanism of action of a citrus extract against *Escherichia coli* and *Listeria monocytogenes*. *J Appl Microbiol*. 2009;106(4):1343-9.
 13. Boyce JM, Pittet D. Guideline for hand hygiene in health-care settings. *MMWR Recomm Rep*. 2002;51(RR-16):1-45.
 14. Bhattacharya J, Dey A, Majumdar S. Herbal hand sanitizers: A sustainable approach to hand hygiene. *Int J Pharm Sci Res*. 2021;12(7):3489-98.
 15. Sharma VK, Yngard RA, Lin Y. Silver nanoparticles: Green synthesis and their antimicrobial activities. *Adv Colloid Interface Sci*. 2009;145(1-2):83-96.
 16. Chaloupka K, Malam Y, Seifalian AM. Nanosilver as a new generation of nanoparticle in biomedical applications. *Trends Biotechnol*. 2010;28(11):580-8.
 17. Bhattacharya P, Gupta A, Das P. Silver nanoparticles in plant-based hand sanitizers: The future of hand hygiene. *J Pharm Res*. 2020;14(3):112-20.
 18. Pittet D, Allegranzi B, Storr J, et al. 'Clean care is safer care': The global patient safety challenge 2005-2006. *Int J Infect Dis*. 2006;10(6):419-24.

HOW TO CITE: Prassanna Bhadange, Vinayak Bhavsar, Vaishnavi Bohade, Nikhil Kadam*, Yash Bachhav, Ritesh Karmarkar, Development of Alcohol-Free Herbal Sanitizer Using Silver Nanoparticles: A Sustainable Approach to Hand Hygiene, *Int. J. of Pharm. Sci.*, 2025, Vol 3, Issue 3, 109-114. <https://doi.org/10.5281/zenodo.14958915>

