

# Formulation and Evaluation of Herbal Hand Sanitizer

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**Abstract:** Herbal hand sanitizers are widely used for maintaining hand hygiene and preventing the spread of infectious microorganisms. The present study was aimed at the formulation and evaluation of a herbal hand sanitizer using natural ingredients such as Neem, Tulsi, and Aloe vera. These herbal ingredients possess significant antimicrobial, antioxidant, and moisturizing properties which make them suitable for hand sanitizer preparations.

The formulation was prepared using ethanol, aloe vera gel, neem extract, tulsi extract, glycerin, lemon oil, and distilled water. The prepared sanitizer was evaluated for various parameters including color, odor, appearance, pH, viscosity, spreadability, antimicrobial activity, skin irritation, foam height, evaporation time, and stability. The formulation showed good physical appearance, acceptable pH, satisfactory spreadability, effective antimicrobial activity, and no signs of skin irritation.

The study concluded that the formulated herbal hand sanitizer was safe, effective, economical, and eco-friendly. The incorporation of herbal ingredients improved antimicrobial activity while reducing skin dryness commonly associated with synthetic sanitizers. Therefore, herbal hand sanitizer can be considered a suitable alternative for regular hand hygiene practices.

**Keywords:** Herbal Hand Sanitizer, Neem, Tulsi, Aloe Vera, Antimicrobial Activity, Hand Hygiene, Herbal Formulation

## I. INTRODUCTION

Hand hygiene is considered one of the most important and effective methods for preventing the spread of infectious diseases and maintaining personal health. Human hands come in direct contact with various contaminated surfaces, objects, food materials, and infected individuals throughout the day. Due to this continuous exposure, hands become the major carriers of pathogenic microorganisms such as bacteria, viruses, and fungi. These microorganisms can easily enter the body through the mouth, nose, eyes, or damaged skin and may cause several infectious diseases. Therefore, proper hand sanitation is essential to reduce microbial transmission and maintain overall hygiene<sup>[1]</sup>.

Traditionally, hand washing with soap and water has been the primary method used for cleaning hands. Although hand washing is highly effective, it may not always be possible in situations where water and soap are unavailable. In such conditions, hand sanitizers provide a convenient, rapid, and effective alternative for maintaining hand hygiene. Hand sanitizers are formulations designed to reduce or eliminate microorganisms present on the skin surface. They are widely used in hospitals, clinics, schools, industries, households, and public places for infection control<sup>[2]</sup>.

Alcohol-based hand sanitizers are among the most commonly used sanitizing products due to their rapid antimicrobial action. Ethanol and isopropyl alcohol are frequently used because they effectively destroy microorganisms by denaturing proteins and disrupting cell membranes. According to the World Health Organization (WHO), alcohol concentration between 60–80% is highly effective against many harmful microorganisms<sup>[3]</sup>.

However, frequent use of synthetic alcohol-based sanitizers may produce several side effects such as dryness, skin irritation, itching, redness, and allergic reactions. Continuous exposure to alcohol and synthetic chemicals may damage the natural protective barrier of the skin, resulting in roughness and dehydration. In addition, some synthetic additives and preservatives present in commercial sanitizers may produce toxic effects after prolonged use<sup>[4]</sup>.



To overcome these disadvantages, herbal hand sanitizers have gained considerable importance in recent years. Herbal formulations contain natural plant extracts possessing antimicrobial, antioxidant, anti-inflammatory, and moisturizing properties. Herbal products are generally considered safer, economical, biodegradable, eco-friendly, and less irritating compared to synthetic formulations. Due to increasing awareness regarding natural healthcare products, the demand for herbal sanitizers has increased significantly worldwide<sup>[5]</sup>.

Medicinal plants have been used in traditional systems of medicine since ancient times because of their therapeutic benefits. Several medicinal herbs possess strong antimicrobial activity against pathogenic microorganisms and are therefore suitable for use in hand sanitizer formulations. Commonly used herbs in herbal sanitizers include Neem, Tulsi, Aloe vera, turmeric, clove, and lemon oil. These herbs contain active phytochemical constituents such as alkaloids, flavonoids, tannins, glycosides, terpenoids, and essential oils responsible for antimicrobial and antioxidant activities<sup>[6]</sup>.

Neem (*Azadirachta indica*) is one of the most valuable medicinal plants widely used in herbal medicine. Neem contains active constituents such as azadirachtin, nimbin, and nimbidin which exhibit antibacterial, antifungal, antiviral, and anti-inflammatory properties. Neem extract is effective against several pathogenic microorganisms and is commonly incorporated into cosmetic and pharmaceutical preparations<sup>[7]</sup>.

Tulsi (*Ocimum sanctum*), also known as Holy Basil, is another important medicinal herb used in traditional medicine. Tulsi possesses antimicrobial, antioxidant, anti-inflammatory, and immunomodulatory activities. The presence of compounds such as eugenol and ursolic acid contributes to its therapeutic importance. Tulsi helps inhibit growth of harmful microorganisms and improves the effectiveness of herbal formulations<sup>[8]</sup>.

Aloe vera is widely used in pharmaceutical and cosmetic preparations because of its moisturizing, soothing, and wound-healing properties. Aloe vera gel contains vitamins, enzymes, amino acids, and polysaccharides that help maintain skin hydration and reduce dryness caused by alcohol. Incorporation of aloe vera in hand sanitizer formulations improves skin compatibility and enhances user comfort during frequent application<sup>[9]</sup>.

Essential oils such as Lemon oil and clove oil are also used in herbal hand sanitizers because of their pleasant fragrance and antimicrobial properties. Lemon oil contains limonene and citral which contribute to antimicrobial activity and provide refreshing aroma to the formulation<sup>[10]</sup>.

The formulation of herbal hand sanitizer requires proper selection of ingredients to ensure effectiveness, safety, stability, and user acceptability. Evaluation parameters commonly include appearance, color, odor, pH, viscosity, spreadability, antimicrobial activity, skin irritation test, evaporation time, foam height, and stability study<sup>[11]</sup>.

The present project focuses on the formulation and evaluation of a herbal hand sanitizer using natural herbal ingredients. The study also aims to evaluate various physical and antimicrobial parameters to ensure safety, quality, and effectiveness of the herbal hand sanitizer for regular use. To formulate a herbal hand sanitizer using natural plant extracts such as Neem, Tulsi, and Aloe vera with effective antimicrobial properties<sup>[5]</sup>.

- To evaluate the prepared formulation for physical parameters including color, odor, pH, viscosity, and spreadability to ensure product quality and stability<sup>[6]</sup>.
- To study the antimicrobial activity of the herbal hand sanitizer against common microorganisms responsible for skin infections and contamination<sup>[7]</sup>.
- To develop a skin-friendly and safe sanitizer formulation with minimum irritation and good moisturizing effect for regular use<sup>[8]</sup>.
- To promote the use of herbal products as eco-friendly and cost-effective alternatives to synthetic hand sanitizers<sup>[9]</sup>.



### **Aim and Objectives**

**AIM:** Formulation and Evaluation of Herbal Hand Sanitizer.

### **Objectives**

- To prepare a herbal hand sanitizer formulation using natural medicinal plant extracts with effective antimicrobial properties for maintaining proper hand hygiene <sup>[12]</sup>.
- To incorporate herbal ingredients such as Neem, Tulsi, and Aloe vera in order to obtain antimicrobial, antioxidant, and moisturizing effects in the formulation <sup>[13]</sup>.
- To formulate a hand sanitizer that provides protection against harmful microorganisms while minimizing skin dryness and irritation commonly associated with synthetic alcohol-based sanitizers <sup>[14]</sup>.
- To evaluate the prepared herbal hand sanitizer for different physicochemical parameters including color, odor, appearance, pH, viscosity, spreadability, and stability <sup>[15]</sup>.
- To study the antimicrobial activity of the formulation against common pathogenic microorganisms responsible for contamination and infections <sup>[16]</sup>.
- To assess the safety and skin compatibility of the prepared formulation by performing skin irritation studies <sup>[17]</sup>.
- To develop an economical, eco-friendly, and user-friendly herbal sanitizer suitable for regular use in homes, hospitals, educational institutions, and public places <sup>[18]</sup>.
- To encourage the use of herbal products as safer alternatives to synthetic sanitizers by utilizing naturally available medicinal plants with therapeutic importance <sup>[19]</sup>.

## **II. LITERATURE REVIEW**

Herbal products have been used since ancient times for the prevention and treatment of various diseases. Medicinal plants contain several bioactive compounds such as alkaloids, flavonoids, tannins, terpenoids, glycosides, and essential oils that possess antimicrobial, antioxidant, anti-inflammatory, and healing properties. In recent years, the use of herbal formulations in pharmaceutical and cosmetic preparations has increased significantly because of their safety, effectiveness, affordability, and minimal side effects compared to synthetic products <sup>[20]</sup>.

Hand hygiene is one of the most effective preventive measures against transmission of infectious microorganisms. Human hands continuously come into contact with contaminated surfaces and act as carriers for bacteria, viruses, and fungi. The use of hand sanitizers helps reduce microbial load and prevents spread of infections. Commercial alcohol-based sanitizers are widely used due to their rapid antimicrobial action. However, repeated use of synthetic sanitizers may lead to skin dryness, irritation, redness, itching, and allergic reactions because of high alcohol concentration and synthetic additives <sup>[21]</sup>.

To overcome these limitations, researchers have focused on the development of herbal hand sanitizers containing natural plant extracts with antimicrobial and moisturizing properties. Herbal sanitizers are considered safer and more skin-friendly because they utilize naturally occurring phytoconstituents. In addition, herbal formulations are biodegradable, eco-friendly, and economical <sup>[22]</sup>.

Neem (*Azadirachta indica*) is one of the most commonly used medicinal plants in herbal formulations. Neem contains important phytochemical constituents such as azadirachtin, nimbin, nimbidin, quercetin, and flavonoids which exhibit potent antibacterial, antifungal, antiviral, and anti-inflammatory activities. Neem extract has been reported to inhibit growth of several pathogenic microorganisms including *Staphylococcus aureus*, *Escherichia coli*, and *Candida* species. Due to these properties, neem is extensively used in herbal soaps, creams, toothpaste, and hand sanitizers <sup>[23]</sup>.

Tulsi (*Ocimum sanctum*), also known as Holy Basil, is regarded as an important medicinal herb in traditional systems of medicine. Tulsi possesses antimicrobial, antioxidant, anti-inflammatory, antipyretic, and immunomodulatory activities. Active compounds such as eugenol, ursolic acid, carvacrol, and linalool contribute to its medicinal value.



Studies have shown that tulsi extract is effective against a variety of bacteria and fungi responsible for skin infections and contamination [24].

Aloe vera is widely utilized in pharmaceutical and cosmetic industries because of its soothing and moisturizing properties. Aloe vera gel contains amino acids, vitamins, minerals, enzymes, and polysaccharides that help maintain skin hydration and promote healing. In hand sanitizer formulations, aloe vera reduces the drying effect caused by alcohol and improves skin smoothness and comfort during repeated use [25].

Essential oils are also important ingredients in herbal sanitizer formulations. Lemon oil contains compounds such as limonene and citral which possess antimicrobial and antioxidant activities. Lemon oil provides refreshing fragrance and enhances the acceptability of the product. Similarly, clove oil and eucalyptus oil are used in herbal formulations because of their antimicrobial effects [26].

Alcohol remains an important component in hand sanitizers because it provides rapid disinfection by denaturing microbial proteins and disrupting cell membranes. According to WHO guidelines, ethanol concentration between 60–80% is considered effective against many harmful microorganisms. However, addition of herbal extracts and moisturizers improves safety and reduces adverse effects associated with continuous alcohol use [27].

Several studies have reported that herbal hand sanitizers prepared with neem, tulsi, aloe vera, and essential oils demonstrate satisfactory antimicrobial activity against pathogenic microorganisms. Researchers observed that these formulations possess good spreadability, acceptable pH, pleasant odor, and skin compatibility. Herbal sanitizers are therefore considered promising alternatives to synthetic sanitizers for maintaining proper hand hygiene [28].

The quality and effectiveness of herbal hand sanitizers depend upon proper formulation and evaluation. Various evaluation parameters such as appearance, color, odor, pH, viscosity, spreadability, antimicrobial activity, evaporation time, foam height, irritancy test, and stability study are performed to ensure quality, safety, and efficacy of the final product [29].

Thus, the available literature suggests that herbal hand sanitizers formulated using medicinal plants provide effective antimicrobial action along with additional benefits such as moisturization, reduced skin irritation, eco-friendliness, and better patient acceptability. These properties make herbal sanitizers suitable for routine use in hospitals, educational institutions, households, and public places [30].

### Material Required

Sr.No.	Material	Quantity	Use
1.	Aloe Vera Gel	20 mL	Moisturizing agent and base material
2.	Neem extract	5 mL	Antibacterial and antifungal agent
3.	Tulsi extract	5 mL	Antimicrobial and antioxidant agent
4.	Ethanol (70%)	60 mL	Main sanitizing and disinfecting agent
5.	Glycerin	5 mL	Humectant and skin softener
6.	Lemon oil	2-3 drops	Fragrance and antimicrobial activity
7.	Distilled water	q. s. to 100 mL	Vehicle and volume adjustment
8.	Carbapol (optional)	0.5 g	Thickening agent for gel consistency
9.	Triethanolamine (optional)	Few drops	pH adjustment and gel formation

### Equipment Required

Sr. No.	Equipment	Use
1.	Beaker	Mixing ingredients
2.	Measuring cylinder	Measuring liquids
3.	Glass rod	Stirring solution
4.	Funnel	Filling bottles



5.	Weighing balance	Accurate weighing
6.	pH meter	Measuring pH
7.	Viscometer	Measuring viscosity
8.	Filter paper	Filtration of extracts

**Method of Preparation**

The herbal hand sanitizer was prepared by using medicinal plant extracts along with alcohol, moisturizing agents, and other supporting ingredients. Proper care was taken during formulation to maintain cleanliness, uniformity, and stability of the final product. The complete preparation process involved collection of herbal materials, extraction of active constituents, preparation of sanitizer base, incorporation of ingredients, and packaging of the final formulation <sup>[31]</sup>.

**Step 1: Collection of Herbal Materials**

Fresh leaves of Neem and Tulsi were collected from a clean and contamination-free environment. Healthy leaves were selected because damaged or infected leaves may reduce quality of the formulation. Collection of suitable herbal material is important to obtain maximum therapeutic and antimicrobial activity from plant extracts <sup>[32]</sup>.



**Fig 1: Herbal plants**

**Step 2: Washing of Plant Materials**

The collected leaves were washed thoroughly using tap water followed by distilled water in order to remove dust particles, soil, microbes, and other impurities present on the surface. Proper washing helps obtain pure herbal extracts and prevents contamination during formulation preparation <sup>[33]</sup>.



**Fig 2. Washing Plant Material**



**Step 3: Shade Drying**

After washing, the leaves were spread uniformly on clean trays and dried under shade at room temperature for approximately four to five days. Direct sunlight was avoided because exposure to excessive heat may destroy sensitive phytochemical constituents such as flavonoids, tannins, alkaloids, glycosides, and essential oils present in medicinal plants.

Shade drying also helps prevent fungal growth and preserves the therapeutic activity of plant materials [34].

**Step 4: Preparation of Powder**

The completely dried neem and tulsi leaves were separately ground using a grinder to obtain coarse powder. Powdering increases the surface area of plant material which helps improve extraction efficiency of active phytoconstituents.

The prepared powders were stored in airtight containers to protect them from moisture, contamination, and environmental exposure until further use [35].

**1. Neem Powder**

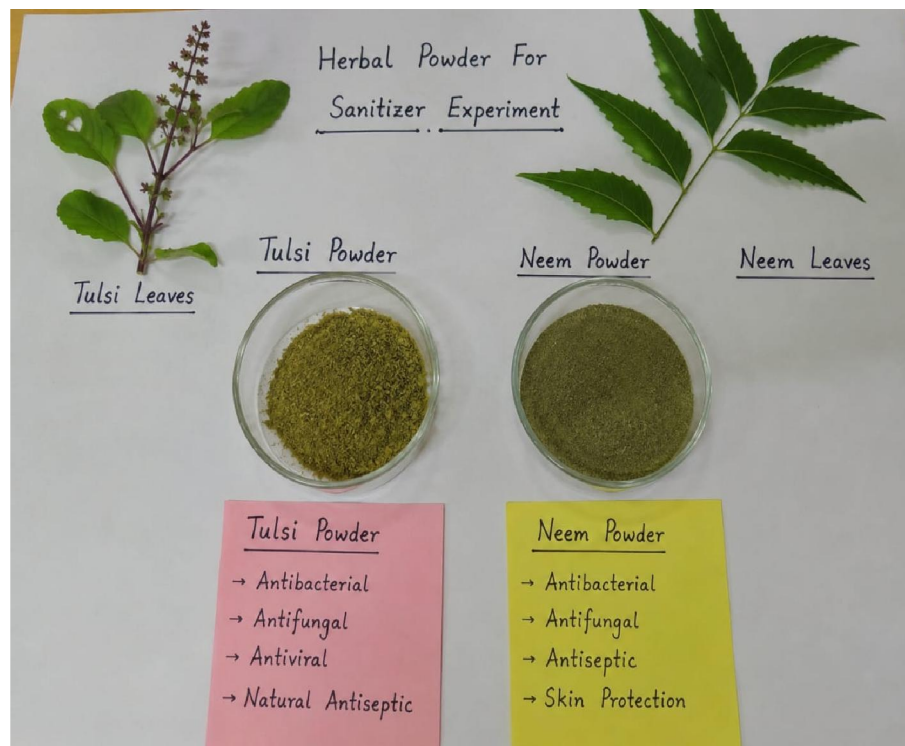
Family- Meliaceae

Neem powder is prepared from dried neem leaves and is widely used in herbal formulations because of its antimicrobial, antifungal, and antiseptic properties. It is commonly used in herbal sanitizers, soaps, face packs, creams, and medicinal preparations.

**2. Tulsi Powder**

Family: Lamiaceae

Tulsi is an important medicinal plant widely used in herbal formulations due to its antibacterial, antifungal, antiviral, and antioxidant properties.



**Fig 3: Herbal Powder Form**



**Step 5: Extraction of Herbal Constituents**

Approximately 10 g of neem powder and 10 g of tulsi powder were taken separately in clean beakers. About 50–100 mL of ethanol or distilled water was added to each beaker and the mixtures were stirred properly. The mixtures were kept undisturbed for 24 hours to allow extraction of active constituents from plant materials into the solvent. During this process, the solvent penetrates the cellular structure of plant tissues and dissolves bioactive compounds responsible for antimicrobial activity<sup>[36]</sup>.

After completion of extraction, the mixtures were filtered using muslin cloth followed by filter paper to obtain clear and particle-free extracts. The prepared extracts were collected separately and stored for further formulation<sup>[37]</sup>.



Fig No: 4 Herbal Extraction Of Tulsi and Neem

**Step 6: Preparation of Sanitizer Base**

A measured quantity of Aloe vera gel was taken in a clean and dry beaker. Aloe vera acts as a natural moisturizer and soothing agent that reduces dryness and irritation caused by alcohol.

Glycerin was added slowly into the aloe vera gel while stirring continuously using a glass rod. Glycerin functions as a humectant and helps maintain moisture content of the skin. Continuous stirring produced a smooth and uniform gel base<sup>[38]</sup>.

**Step 7: Addition of Alcohol**

Measured quantity of ethanol (70%) was added gradually into the prepared gel base with continuous stirring. Ethanol acts as the main disinfecting agent in the formulation and helps destroy harmful microorganisms by denaturing microbial proteins and disrupting cell membranes.

Slow addition of alcohol prevents formation of lumps and ensures proper mixing throughout the formulation<sup>[39]</sup>.

**Step 8: Incorporation of Herbal Extracts**

Prepared neem and tulsi extracts were added slowly into the sanitizer base with continuous stirring. Proper mixing was carried out to ensure uniform distribution of herbal constituents throughout the formulation.

Neem extract provides antibacterial, antiviral, and antifungal properties, whereas tulsi extract contributes antimicrobial and antioxidant activities. These herbal ingredients improve effectiveness of the sanitizer and provide additional skin benefits<sup>[40]</sup>.



**Step 9: Addition of Fragrance and Essential Oil**

Few drops of Lemon oil were added to the formulation to provide pleasant fragrance and refreshing effect. Lemon oil also contributes antimicrobial activity because of the presence of active compounds such as limonene and citral. The formulation was stirred continuously to achieve uniform distribution of fragrance throughout the sanitizer <sup>[41]</sup>.

**Step 10: Volume Adjustment**

Distilled water was added gradually to adjust the final volume of the formulation up to 100 mL. Continuous stirring was maintained during this process to obtain uniform consistency and homogeneity.

The formulation was carefully observed to ensure absence of phase separation, precipitation, or formation of coarse particles <sup>[42]</sup>.

**Step 11: Packaging of Formulation**

The prepared herbal hand sanitizer was transferred carefully into sterilized airtight plastic bottles using a funnel. Proper sterilization of containers helps prevent microbial contamination and maintains stability of the product.

The containers were labeled appropriately with formulation name, date of preparation, and storage instructions <sup>[43]</sup>.

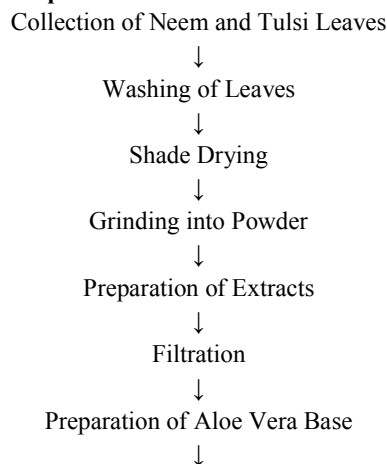


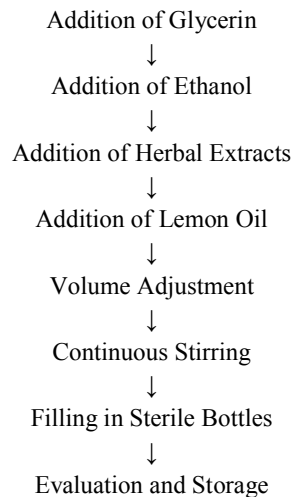
**Fig No : 4 Herbal Formulation Hand Sanitizere**

**Step 12: Storage of Formulation**

The prepared sanitizer was stored at room temperature away from direct sunlight, moisture, and excessive heat. Proper storage conditions help maintain physical appearance, antimicrobial activity, pH, consistency, and stability of the formulation for a longer duration. Periodic observations were made during storage to check for any changes in color, odor, consistency, and phase separation <sup>[44]</sup>.

**Flow Chart Of Herbal Hand Sanitizer Preparation**





### **Evaluation Tests**

Evaluation of herbal hand sanitizer is an important process carried out to determine the quality, safety, effectiveness, stability, and acceptability of the prepared formulation. Various physical, chemical, and microbiological parameters are evaluated to ensure that the sanitizer provides effective antimicrobial action while remaining safe and comfortable for regular use on the skin. Proper evaluation also helps in maintaining product quality and stability during storage<sup>[45]</sup>.

#### **1. Organoleptic Evaluation**

Organoleptic evaluation was performed to examine the physical characteristics of the prepared herbal hand sanitizer. Parameters such as color, odor, appearance, texture, clarity, and consistency were observed visually.

The formulation should possess uniform appearance, smooth texture, and pleasant herbal odor without any precipitation, phase separation, or formation of lumps. This evaluation helps determine user acceptability and aesthetic quality of the product. A clear and attractive formulation improves consumer satisfaction and product acceptance<sup>[46]</sup>.

#### **2. Determination of pH**

The pH of the prepared sanitizer was determined using a calibrated digital pH meter. The pH of topical formulations plays an important role in maintaining skin compatibility and preventing irritation.

A small quantity of sanitizer was diluted with distilled water and the pH was measured at room temperature. The ideal pH range for herbal hand sanitizer should be close to skin pH, generally between 6 and 7. Formulations having extremely acidic or alkaline pH may cause redness, dryness, itching, or irritation after repeated use<sup>[47]</sup>.

#### **3. Viscosity Test**

Viscosity test was performed to determine the thickness and flow property of the sanitizer formulation. Proper viscosity ensures easy handling, smooth application, and sufficient retention time on the skin surface.

The viscosity of the formulation was measured using a Brookfield viscometer. A sanitizer with very low viscosity may spread excessively and evaporate quickly, whereas extremely high viscosity may create difficulty during application. Therefore, moderate viscosity is considered suitable for ideal hand sanitizer formulations<sup>[48]</sup>.

#### **4. Spreadability Test**

Spreadability test was carried out to evaluate the ease with which the sanitizer spreads over the skin surface. Good spreadability ensures uniform application of the formulation and improves convenience during use.

A small quantity of sanitizer was placed between two glass slides and slight pressure was applied. The extent and ease of spreading were observed carefully. Proper spreadability allows better coverage of the skin surface and improves antimicrobial effectiveness<sup>[49]</sup>.



### **5. Antimicrobial Activity**

Antimicrobial activity is one of the most important evaluation parameters for hand sanitizers because it determines the effectiveness of the formulation against pathogenic microorganisms.

The antimicrobial activity of the prepared herbal hand sanitizer was evaluated using agar well diffusion method. Nutrient agar plates inoculated with bacterial cultures were prepared and wells were made in the agar medium. The sanitizer sample was introduced into the wells and plates were incubated for a specified period.

After incubation, the zone of inhibition formed around the wells was measured. A larger zone of inhibition indicated stronger antimicrobial activity of the formulation against microorganisms. Presence of herbal extracts such as Neem and Tulsi enhanced the antimicrobial effectiveness of the sanitizer <sup>[50]</sup>.

### **6. Skin Irritation Test**

Skin irritation test was performed to determine the safety and compatibility of the formulation on human skin.

A small amount of sanitizer was applied on a limited area of skin and observed for signs of redness, itching, burning sensation, inflammation, or swelling for a certain period. The absence of irritation indicated that the prepared formulation was safe for topical application and suitable for regular use <sup>[51]</sup>.

### **7. Stability Study**

Stability study was carried out to determine the stability of the formulation under storage conditions over a period of time.

The prepared sanitizer was stored at room temperature and observed periodically for changes in color, odor, pH, viscosity, consistency, and phase separation. Stability studies are important to determine shelf life, storage conditions, and overall quality maintenance of the product during storage <sup>[52]</sup>.

### **8. Foam Height Test**

Foam height test was performed to evaluate the foaming property of the formulation. Although hand sanitizers generally produce less foam compared to soaps, moderate foam formation increases user satisfaction and cleansing perception.

The formulation was shaken in a graduated measuring cylinder and the height of foam produced was recorded after a specific time interval. Stable and moderate foam height indicated satisfactory foaming property of the formulation <sup>[53]</sup>.

### **9. Evaporation Time Test**

Evaporation time test was performed to determine the rate of drying of sanitizer after application on the skin.

A measured quantity of sanitizer was applied on the hands and the time required for complete evaporation was recorded. Rapid evaporation indicates proper alcohol concentration and quick antimicrobial action. Fast drying property also improves convenience during regular use <sup>[54]</sup>.

### **10. Homogeneity Test**

Homogeneity test was carried out to determine uniform distribution of ingredients within the formulation.

The prepared sanitizer was visually examined for aggregates, coarse particles, lumps, and phase separation. A homogeneous formulation indicates proper mixing of ingredients and better stability of the product <sup>[55]</sup>.

### **11. Texture and Consistency Test**

Texture and consistency of the prepared sanitizer were evaluated manually by rubbing a small quantity between fingers.

The formulation should possess smooth texture, non-sticky nature, and suitable consistency for comfortable application on the skin. Proper texture improves user acceptability and ease of use <sup>[56]</sup>.

### **12. Washability Test**

Washability test was carried out to determine ease of removal of formulation from the skin surface when washed with water.

A small quantity of sanitizer was applied on the skin and later washed with water to observe removal characteristics. Good washability indicates convenience and better hygiene maintenance <sup>[57]</sup>.



**Observation Table**

Sr.No.	Evaluation Parameter	Observation	Use
1.	Color	Light green	Acceptable
2.	Odor	Pleasant Herbal odor	Acceptable
3.	Appearance	Smooth and clear	Good
4.	Consistency	Semi-liquid gel	Satisfactory
5.	pH	6.5	Suitable for skin
6.	Viscosity	Moderate	Good Spreadability
7.	Spreadability	Easily spreadable	Good
8.	Antimicrobial Activity	Zone of inhibition observed	Effective
9.	Skin Irritation Test	No redness or irritation	Safe
10.	Stability Study	No phase separation or color change	Stable
11.	Foam Height	Moderate foam observed	Acceptable
12.	Evaporation Time	20-30 seconds	Fast drying

**Advantages of Herbal Hand Sanitizer**

Herbal hand sanitizers provide several benefits because they contain natural medicinal plant extracts with antimicrobial and skin-protective properties. These formulations are considered safer and skin-friendly compared to synthetic sanitizers containing excessive chemicals <sup>[58]</sup>.

**1. Natural and Safe Formulation**

Herbal hand sanitizers are prepared using natural ingredients such as Neem, Tulsi, and Aloe vera which possess therapeutic and antimicrobial properties. Natural ingredients reduce the chances of harmful side effects associated with prolonged use of synthetic chemicals <sup>[59]</sup>.

**2. Effective Antimicrobial Activity**

Medicinal herbs contain phytochemical constituents such as alkaloids, flavonoids, tannins, glycosides, and essential oils that exhibit antibacterial, antifungal, and antiviral activities. These compounds help eliminate harmful microorganisms present on the skin surface and maintain proper hand hygiene <sup>[60]</sup>.

**3. Reduced Skin Dryness**

Repeated use of synthetic alcohol-based sanitizers may lead to excessive dryness and roughness of the skin. Herbal formulations containing aloe vera gel and glycerin help maintain moisture content of the skin and reduce dryness caused by alcohol <sup>[61]</sup>.

**4. Skin-Friendly and Non-Irritating**

Herbal sanitizers are generally mild and compatible with the skin. Presence of natural ingredients reduces chances of itching, redness, burning sensation, and allergic reactions during repeated application <sup>[62]</sup>.

**5. Eco-Friendly Nature**

Herbal hand sanitizers are biodegradable and environmentally friendly because they contain naturally derived ingredients. They produce less environmental pollution compared to synthetic chemical formulations <sup>[63]</sup>.

**6. Pleasant Herbal Fragrance**

Essential oils such as Lemon oil provide refreshing fragrance to the formulation and improve user satisfaction. Natural fragrances also reduce unpleasant odor associated with some synthetic sanitizers <sup>[64]</sup>.

**7. Economical Preparation**

Most medicinal plants used in herbal sanitizer formulations are easily available and inexpensive. Therefore, herbal sanitizers can be prepared economically at laboratory and household level <sup>[65]</sup>.

**8. Additional Therapeutic Benefits**

Many herbal ingredients possess antioxidant, anti-inflammatory, and wound-healing properties. These additional therapeutic effects help protect and maintain healthy skin during frequent sanitizer use <sup>[66]</sup>.



#### 9. Better User Acceptability

Due to smooth texture, soothing effect, and natural composition, herbal hand sanitizers are preferred by many individuals for routine use. Reduced skin irritation improves patient compliance and acceptability<sup>[67]</sup>.

#### 10. Easy Availability of Herbal Materials

Medicinal plants such as neem and tulsi are widely available and can be cultivated easily. Availability of herbal materials makes preparation of sanitizer simple and convenient<sup>[68]</sup>.

### **Disadvantages of Herbal Hand Sanitizer**

Although herbal hand sanitizers possess several advantages, they also have certain limitations related to stability, standardization, and storage conditions<sup>[69]</sup>.

#### 1. Short Shelf Life

Herbal formulations generally possess shorter shelf life compared to synthetic products because natural ingredients may degrade during prolonged storage. Changes in color, odor, and consistency may occur over time<sup>[70]</sup>.

#### 2. Possibility of Microbial Contamination

Improper preparation and storage conditions may increase chances of microbial contamination in herbal formulations. Natural ingredients may support microbial growth if proper preservation techniques are not followed<sup>[71]</sup>.

#### 3. Variation in Herbal Constituents

The concentration of active phytochemical constituents in medicinal plants may vary depending upon climate, geographical conditions, harvesting season, and storage conditions. Such variations may affect antimicrobial effectiveness of the final formulation<sup>[72]</sup>.

#### 4. Stability Problems

Certain herbal constituents are sensitive to heat, light, air, and moisture. Exposure to unfavorable environmental conditions may reduce stability and therapeutic activity of the sanitizer<sup>[73]</sup>.

#### 5. Strong Herbal Odor

Some herbal extracts possess strong natural odor which may not be preferred by all users. Although essential oils are added to improve fragrance, certain individuals may still dislike the smell<sup>[74]</sup>.

#### 6. Slower Action Compared to Synthetic Sanitizers

In some cases, herbal sanitizers may exhibit slower antimicrobial activity compared to highly concentrated synthetic alcohol-based sanitizers. Effectiveness depends upon quality and concentration of herbal extracts used<sup>[75]</sup>.

#### 7. Difficulty in Standardization

Standardization of herbal formulations is difficult because plant extracts contain multiple active constituents. Maintaining uniformity in every batch may therefore become challenging<sup>[76]</sup>.

#### 8. Possibility of Allergic Reactions

Although herbal products are generally safer, some individuals may develop hypersensitivity or allergic reactions to certain plant extracts or essential oils present in the formulation<sup>[77]</sup>.

#### 9. Requirement of Proper Storage

Herbal hand sanitizers require proper storage away from direct sunlight, moisture, and excessive heat to maintain stability and effectiveness during storage<sup>[78]</sup>.

#### 10. Limited Commercial Stability

Compared to commercial synthetic sanitizers containing strong preservatives and stabilizers, herbal sanitizers may require additional care to maintain long-term stability and shelf life<sup>[79]</sup>.

## **II. CONCLUSION**

The present study successfully demonstrated the formulation and evaluation of a herbal hand sanitizer using natural ingredients such as Neem, Tulsi, and Aloe vera. The prepared formulation showed satisfactory physical appearance,



good consistency, pleasant odor, acceptable pH, proper spreadability, and effective antimicrobial activity against harmful microorganisms<sup>[80]</sup>.

Incorporation of herbal extracts provided additional therapeutic benefits such as antibacterial, antifungal, antioxidant, and soothing properties. Presence of aloe vera and glycerin helped reduce dryness and irritation commonly associated with repeated use of alcohol-based sanitizers. The formulation was also found to be skin-friendly and suitable for routine application without causing noticeable irritation or discomfort<sup>[81]</sup>.

Evaluation studies confirmed that the prepared sanitizer possessed good stability and maintained its quality during storage under suitable conditions. The use of herbal ingredients improved safety and minimized harmful effects associated with synthetic chemical formulations<sup>[82]</sup>.

Herbal hand sanitizers can therefore serve as effective, economical, biodegradable, and eco-friendly alternatives to synthetic sanitizers for maintaining proper hand hygiene and preventing spread of infectious microorganisms. Increasing awareness regarding natural healthcare products and personal hygiene may further promote the use of herbal formulations in pharmaceutical and cosmetic industries<sup>[83]</sup>.

Thus, the prepared herbal hand sanitizer may be considered a safe and effective formulation for routine hand hygiene practices in homes, hospitals, educational institutions, workplaces, and public places<sup>[84]</sup>.

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