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# A Systematic Study of Classification, Activity and Phytochemistry of Natural Ingredients Used in Herbal Sanitizer: Review

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**ABSTRACT**

The comprehensive study of herbal sanitizers presents a detailed exploration of the formulation, benefits, and efficacy of herbal-based sanitizers as alternatives to conventional chemical-based options. This review begins with an introduction to sanitization, tracing its historical significance and highlighting the growing need for effective hand hygiene, especially in the wake of global health concerns. The article examines various sanitization techniques available in the market, including devices and formulations, to provide a broader understanding of hygiene solutions. A classification of sanitizers is provided, with a comparison between chemical and herbal types, emphasizing the advantages of herbal formulations, such as reduced side effects and eco-friendliness. Key herbal ingredients, including their botanical sources, phytochemistry, and extraction methods, are discussed in detail, alongside excipients used in formulations. Both alcohol-based and non-alcohol-based herbal sanitizers are reviewed, with attention to their antibacterial mechanisms. The antibacterial action of specific herbal components is outlined, demonstrating their efficacy in killing or inhibiting microbial growth. The procedure for preparing herbal sanitizers is systematically described, covering ingredient selection, formulation, and processing methods. The article also details evaluation parameters for herbal sanitizers, including dosage form considerations and biological activity determination, ensuring that the final product meets safety and efficacy standards. Through this review, herbal sanitizers are presented as viable, effective, and sustainable alternatives in the growing demand for personal and public hygiene solutions.

**Keywords :** Herbal Sanitizers, Herbs, Phytochemistry, Antimicrobial, Antifungal, Formulations

## I. INTRODUCTION

Hygiene refers to practices that ensure cleanliness, which is crucial for maintaining health. Proper body hygiene and the use of cleaning products are essential for a healthy lifestyle. A sanitizer is a product designed to reduce or eliminate harmful microorganisms, like bacteria, from surfaces. Hand sanitizers are especially important since hands are a primary area for germ transmission; they frequently touch surfaces, objects, and other people, making it easy to transfer germs to the face, eyes, nose, and mouth. During peak respiratory virus season (approximately October to April), hand sanitizers play a significant role by simplifying hand cleaning. Washing hands every time one sneezes or coughs can be difficult, especially when outdoors or in a vehicle. Hand sanitizers provide a convenient alternative, encouraging people to sanitize their hands more often, which is certainly better than not cleaning at all.[1,3]

Hand sanitizers are commonly utilized by medical professionals, such as doctors and surgeons, both before and after surgeries, as well as by pathologists and researchers. They are also frequently found in restaurants and restrooms. Furthermore, life science colleges make hand sanitizers available in laboratories for students to use after practical classes, promoting hygiene and minimizing the risk of infection. [10]

Hand sanitizers, also known as hand antiseptics, are essential for eliminating pathogens when soap is not available. Their demand surged during the COVID-19 pandemic due to the highly contagious SARS-CoV-2 virus, which can persist in aerosols and on surfaces for long periods, highlighting the importance of effective hand hygiene. While most hand sanitizers contain 60–65% alcohol, higher concentrations of 75–80% may offer greater efficacy. Concerns about harmful additives have sparked interest in natural alternatives, resulting in the creation of herbal, non-alcohol hand sanitizers that effectively combat bacteria while being gentler on the skin. [4,5]

Natural substances with antibacterial properties are commonly included in herbal handwashes and sanitizers. Ingredients like aloe vera, neem, tea tree oil, lavender, and eucalyptus are popular choices. These components are believed to possess antibacterial, antiviral, and antifungal effects, making them effective against various pathogens. An herbal sanitizer is a hand hygiene product that utilizes plant-based ingredients and natural extracts to effectively eliminate or reduce pathogens on the skin. Unlike traditional alcohol-based sanitizers, herbal options often feature essential oils and other botanical compounds known for their antimicrobial properties, offering effective disinfection while being gentler on the skin. [6]

### 1.1. Materials and methods

This review focused on original research articles published in English, examining the formulation and testing of natural hand sanitizers. A thorough search of Google Scholar identified 75 articles. After screening, 10 were excluded due to duplication, and 14 were removed for being ineffective, leaving 51 relevant studies. Data from these 51 articles, including study objectives, classification, methodologies, key findings, and conclusions, were meticulously extracted and summarized to provide updated insights into natural hand sanitizers.

## 2. History

Hand sanitizers were first introduced in healthcare settings in 1966 and gained attraction in the early 1990s. While alcohol has been used as an antiseptic since the late 1800s, the true origins of hand sanitizer are somewhat unclear. Lupe Hernandez is often credited with its invention in 1966, though there is no concrete evidence to support this claim. The German company Hartmann launched Sterillium, the first commercial alcohol-based disinfectant, in 1965. Prior to that, in 1946, Goldie and Jerry Lippman developed Gojo for rubber plant workers, which combined petroleum jelly with a small amount of alcohol. Gojo later created Purell in 1988, which became the best-selling hand sanitizer following its consumer launch in 1997, soon joined by GermX from Vi-Jon Industries. [7]

The history of herbal hand sanitizers is linked to the long-standing use of plants for their medicinal and antimicrobial properties. Many cultures have utilized herbs such as tea tree, eucalyptus, and lavender for centuries, acknowledging their effectiveness in fighting infections. In the late 20th century, a notable shift toward natural and organic products emerged, fueled by consumer demand for safer alternatives to chemical-laden options. This trend led to the development of herbal hand sanitizers in the early 2000s, as manufacturers began incorporating herbal extracts and essential oils into their formulations. [8]

Research validating the effectiveness of various plant extracts in reducing pathogens has further supported these products, facilitating their acceptance in both consumer markets and healthcare settings. The COVID-19 pandemic increased awareness of hand hygiene, driving up demand for herbal and natural sanitizers. Brands started promoting these products as effective alternatives to traditional alcohol-based options, often emphasizing skin-friendly ingredients like aloe vera and chamomile. Today, herbal hand sanitizers blend traditional knowledge with modern science, offering consumers effective and gentle options for hand hygiene. [9]

## 3. Need for Sanitization

The need for sanitization, particularly in healthcare and food handling contexts, is driven by several critical factors:

**1. Prevention of Infection:** Proper sanitization prevents the spread of infectious diseases, protecting patients and staff from healthcare-associated infections (HAIs) in medical settings.

**2. Reduction of Contaminants:** In food handling, sanitization removes harmful microorganisms, preventing foodborne illnesses from pathogens like Salmonella and E. coli.

**3. Public Health:** Effective sanitization practices reduce disease outbreaks, such as norovirus and influenza, and protect vulnerable populations through community awareness.

**4. Compliance with Regulations:** Strict sanitation regulations govern industries like healthcare and food services, essential for maintaining legal compliance and licenses.

**5. Enhanced Safety and Trust:** High sanitization standards build customer trust in businesses, enhancing their reputation and attracting more customers or patients.

**6. Impact of Global Health Events**: The COVID-19 pandemic emphasized the importance of sanitization, leading to widespread adoption of practices to prevent future outbreaks.

**7. Environmental Considerations:** There's a growing demand for eco-friendly sanitizers, reflecting consumer interest in effective products that minimize environmental harm.[10-13]

**4. Different Sanitization Techniques**

Sanitization techniques vary widely based on the environment and purpose. Here are some common methods enlisted for sanitization:

**a. Hand Sanitizing:**

- **Alcohol-Based Sanitizers:** Typically contain 60-80% alcohol; effective in killing most germs on hands.
- **Non-Alcoholic Sanitizers:** Often use alternative active ingredients like benzalkonium chloride; may be gentler on the skin.

**b. Herbal Sanitizers:**

- **Natural Ingredients:** Often include essential oils (like tea tree or eucalyptus) and plant extracts (like aloe vera or neem) known for their antimicrobial properties.
- **Effectiveness:** Varies by formulation; some ingredients have demonstrated antimicrobial activity.
- **Use Cases:** Commonly found in personal care products and household cleaners, appealing to those seeking natural alternatives.

**c. Surface Sanitizing:**

- **Chemical Disinfectants:** Use of bleach, hydrogen peroxide, or quaternary ammonium compounds to disinfect surfaces.
- **Wipes:** Pre-moistened disinfecting wipes for quick sanitation of surfaces.
- **Sprays:** Disinfectant sprays for broader coverage on surfaces.

**d. Ultraviolet (UV) Light:**

- **UV-C Light:** Effective in killing bacteria and viruses by damaging their DNA/RNA, used in air and surface disinfection. Surface sanitation can be done UV light.

**e. Heat Sanitization:**

- **Hot Water:** Washing items in hot water (above 171°F/77°C) can effectively sanitize.
- **Steam Cleaning:** Using steam at high temperatures to kill pathogens on surfaces and fabrics.

**f. Ozone Sanitization:**

- **Ozone Gas:** Utilized for its strong oxidizing properties to disinfect air and surfaces, often in food processing.

**g. Electrolyzed Water:**

➢ **Hypochlorous Acid:** Generated by electrolyzing saltwater, this solution can disinfect surfaces and is safe for food contact.

**h. Fogging and Misting:**

➢ **Disinfectant Foggers:** Create a fine mist of disinfectant to cover large areas quickly, often used in commercial settings.

**i. Biocidal Agents:**

➢ **Natural Sanitizers:** Ingredients like vinegar, essential oils, and plant extracts with antimicrobial properties.

**j. Physical Cleaning:**

➢ **Scrubbing:** Using brushes or cloths to physically remove dirt and microorganisms from surfaces before disinfecting.

**k. Routine Cleaning:**

➢ **Regular Maintenance:** Combining cleaning and sanitizing to ensure surfaces are kept free of dirt and germs.[14-17]

**5. Sanitizers - Available formulations and Dispensing Devices**

**A. Chemical Sanitizers**

**a. Formulations:**

➢ **Liquid Sanitizers:** Solutions containing active ingredients like chlorine or quats, often used for surface cleaning and disinfection.

➢ **Wipes:** Pre-moistened wipes infused with sanitizing solutions, convenient for quick cleaning of surfaces.

➢ **Foams:** Thick, clinging formulations that allow for prolonged contact with surfaces, enhancing effectiveness.

➢ **Sprays:** Easy-to-use aerosol or pump sprays that can cover larger areas, suitable for both hard surfaces and fabrics.

**b. Devices**:

➢ **Dispensing Units:** Wall-mounted or countertop dispensers for liquid sanitizers in public places (e.g., schools, restaurants).

➢ **Foggers:** Devices that create a fine mist of sanitizing solution, ideal for large areas and hard-to-reach spaces.

➢ **Ultrasonic Cleaners**: Use high-frequency sound waves to create microscopic bubbles that can effectively clean and sanitize small items.

**B. Herbal Sanitizers**

**a. Formulations:**

➢ **Hand Sanitizer Gels:** Alcohol-based gels infused with herbal extracts and essential oils for antimicrobial benefits.

➢ **Sprays:** Herbal sanitizing sprays that combine alcohol or vinegar with essential oils for surface cleaning and personal use.

➢ **Wipes:** Herbal-infused wipes that offer convenience for on-the-go sanitization, often made with biodegradable materials.

➢ **Creams:** Hand sanitizers that include moisturizing ingredients along with antimicrobial herbal components.

**b. Devices:**

➢ **Essential Oil Diffusers:** While not traditional sanitizers, some diffusers can disperse essential oils known for their antimicrobial properties, improving air quality.

➢ **Spray Bottles:** Simple spray devices for homemade herbal sanitizers, allowing users to mix their own formulations.

This variety of formulations and devices offers flexibility for both individual and commercial sanitization needs, catering to different preferences and requirements. [18,19]

**6. Classification**

Sanitizers are essential for ensuring hygiene and reducing the spread of germs. They can be categorized into two primary types: Chemical sanitizers and Herbal sanitizers.

Chemical sanitizers are subdivided into alcohol-based and non-alcohol-based options. Alcohol-based sanitizers generally contain ethanol or isopropyl alcohol, which are effective at quickly eliminating bacteria and viruses. In contrast, non-alcohol-based sanitizers use various active ingredients, such as quaternary ammonium compounds or chlorine, providing different disinfection methods.

Herbal sanitizers, meanwhile, gain their antimicrobial effects from natural plant extracts and essential oils. These options attract those who prefer a more natural hygiene solution without synthetic additives. This classification aids consumers in selecting the most suitable sanitizer according to their individual preferences and needs. [20-22]

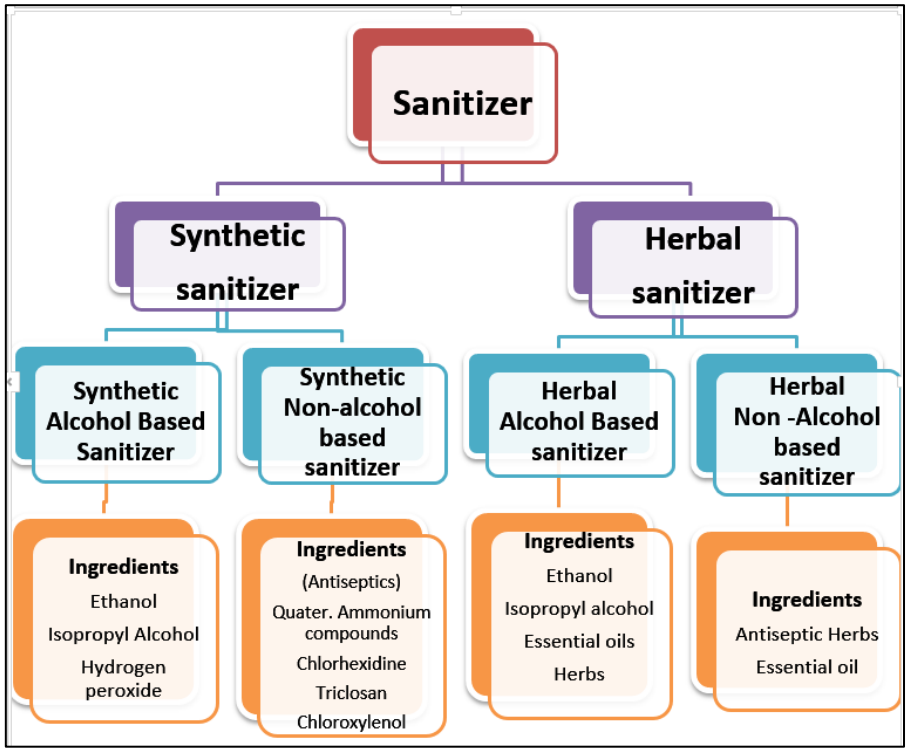


**Fig 1. Classification of Synthetic and Herbal Sanitizer [2,10]**

**7. Comparison of Chemical v/s Herbal Sanitizer** [23]

**7.1 Chemical Sanitizer**

❖ **Advantages**

➢ **Convenience:** Hand sanitizers are portable and easy to use.

- **Health Benefits:** They lower the risk of spreading gastrointestinal and respiratory infections in families.
- **Skin Care:** Many commercial hand sanitizers contain moisturizing ingredients to prevent dry skin.
- **Reduced Absenteeism:** Proper use can decrease classroom absenteeism by 20% by minimizing illness.

❖ **Disadvantages**

- **Skin Irritation:** Alcohol-based hand sanitizers can cause rashes and irritation on the skin.
- **Burning Sensation:** They may sometimes lead to a burning sensation when applied.
- **Dryness:** Frequent use can lead to dry and cracked skin due to the high alcohol content.
- **Allergic Reactions:** Some individuals may experience allergic reactions to certain ingredients in sanitizers.
- **Limited Effectiveness:** Chemical sanitizers may not effectively remove certain types of germs, including some viruses and bacteria that are not alcohol-sensitive.
- **Toxicity Risks:** Ingesting or improperly using sanitizers can pose health risks, especially for children.
- **Environmental Concerns:** Many chemical sanitizers are not environmentally friendly and can contribute to pollution.
- **Flammability:** High alcohol content makes sanitizers flammable, posing safety hazards if near heat sources.
- **Overuse Dependence:** Relying solely on sanitizers may lead to neglecting proper handwashing techniques.

**7.2. Herbal Sanitizers**

❖ **Advantages**

- **Purpose:** Herbal antiseptic products are designed to prevent the transmission of skin infections and pathogens.
- **Moisturizing Effect**: They tend to cause less skin dryness and retain more moisture compared to traditional sanitizers.
- **Additional Benefits:** Herbal ingredients can provide extra beneficial effects beyond basic sanitation.
- **Child Health:** Herbal handwashing can reduce the incidence of illness among young children and help decrease school absenteeism.
- **Illness Prevention:** Regular handwashing with herbal products can help prevent various illnesses. The CDC also emphasizes the importance of getting a yearly flu vaccine as a primary protective measure.
- **Ease of Use:** Effective handwashing is a simple and practical skill that can be easily learned and practiced daily.
- **Bacterial Reduction:** Herbal sanitizers can eliminate about 97% of bacteria on hands.
- **Neem and Tulsi Benefits:** Neem and Tulsi (holy basil) are renowned for their antibacterial, antiviral, and antifungal properties, making them valuable in traditional and Ayurvedic medicine, respectively. Both can be effectively incorporated into hand sanitizers to combat bacteria and microorganisms, enhancing their efficacy in maintaining hand hygiene.

❖ **Disadvantages**

- **Variable Efficacy:** The effectiveness of herbal ingredients can vary, making some formulations less potent against
- certain pathogens.

- **Limited Research:** There may be insufficient scientific research to support the antimicrobial claims of some
- herbal components.
- **Allergic Reactions:** Some individuals may experience allergic reactions to herbal ingredients.
- **Shorter Shelf Life:** Herbal sanitizers may have a shorter shelf life compared to conventional chemical sanitizers.
- **Not a Substitute:** They should not completely replace traditional handwashing or other hygiene measures.
- **Moisture Retention:** While they may retain moisture, excessive use can still lead to skin irritation or sensitivity.

## 8. Ingredients used in Herbal Sanitizer

Sanitizers are crafted from a range of ingredients that enhance their efficacy and attractiveness. Alongside active antimicrobial agents like alcohol or chemical disinfectants, many formulations include herbal components known for their natural germ-fighting properties. Essential oils from plants such as tea tree, lavender, or eucalyptus not only boost antimicrobial effectiveness but also add appealing fragrances.

Furthermore, sanitizers often contain excipient substances that improve the formulation's stability, texture, and ease of use. These may include moisturizers to combat skin dryness, emulsifiers for even ingredient distribution, and thickening agents to achieve the desired consistency. Collectively, these elements contribute to creating a sanitizer that is both effective and pleasant to use, meeting a variety of consumer needs.

### 8.1. Herbs

The use of herbs in sanitizer formulations has garnered interest for their natural antimicrobial properties and health benefits. This overview presents a curated list of herbs sourced from various research studies, detailing their botanical origins, families, key chemical constituents, and applications in sanitization.

By exploring these herbs, we can appreciate their effectiveness as active ingredients in sanitizers, reflecting the increasing shift toward natural alternatives in hygiene products and the role of scientific research in supporting their use. [24,27,31]

**Table No.1: Antimicrobial Herbal Agents: A List of Medically Relevant Plants.**

| Sr no. | Name | Biological Source | Family | Chemical Constituents | Uses |
|---|---|---|---|---|---|
| 1 | Neem | *Azadirachta indica* | Meliaceae | Azadirachtin, Nimbolin, Nimbidin, Sodium nimbinate, Salannin, etc | Inflammation, fever, skin disease & dental disorder. |
| 2 | Aloe vera | *Aloe barbadensis* | Liliaceae | Anthraquinone glycoside, aloin, aloe emodin, aloe resin | Catharctic & laxative properties, also used in a cosmetics. |
| 3 | Garlic | *Allium sativum* | Liliaceae | Allicin, S-propyl cysteine | Expectorant, Stimulant |
| 4 | Amla | *Phyllanthus emblica* | Phyllanthace-ae | Vit C, ellagic acid, chebulinic acid, garlic acid | Anti-diabetic, hypolipidemic, anti-microbial, anti-inflammatory etc. |
| 5 | Turmeric | *Curcuma longa* | Zingiberacea-e | Volatile oil, Curcumin, resin | Anti-inflammatory, condiment, colouring agent. |
| 6 | Ginger | *Zingiber officinale* | Zingiberace-ae | Volatile oil: Bisabolene, Zingiberine, zingiberol | Carminative And Flavouring Agent, Condiment, Stimulant |
| 7 | Kali Haldi | *Curcuma caesia* | Zingiberace-ae | Camphor, ocimene, curcumin etc. | Anti-fungal, antibacterial, leucoderma, inflammation, allergic etc. |
| 8 | Tulsi | *Ocimum sanctum* | Lamiaceae | Volatile oil, eugenol, methyl-eugenol, carvacrol | Antiseptic, expectorant, insecticidal. |

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| 9 | Basil | *Ocimum basilicum* | Lamiaceae | Essential oils, Flavonoids | Prevents cancer. |
| 10 | Mint | *Mentha piperita* | Lamiaceae | Menthyl acetate, isovalerate, menthone, cineol, inactive pinene, limonene, and other less important bodies. | Stimulant, stomachic, carminative, in flatulence, and colic; in some dyspepsia |
| 11 | Oregano | *Origanum vulgare* | Lamiaceae | rosmarinic acid, linalool, thymol, carvacrol, tannins, flavonoids, triterpenes, phenol carvacrol, and thymol. | anti-inflammatory, antioxidant, and antimicrobial properties |
| 12 | Pennyro-yal | *Mentha pulegium* | Lamiaceae | Neomenthol, pulegone and menthone | Antioxidant, Antimicrobial, anti-hepatic, Anti-genotoxic. |
| 13 | Lavende-r oil | *Lavendula angustifolia* | Lamiaceae | Linalool, pinene, cineol. | Aromatic, carminative, flavour |
| 14 | Thyme | *Thymus vulgaris* | Myrtaceae | Thymol, linalool, carvacrol | Antimicrobial, pesticide, |
| 15 | Clove | *Eugenia caryophyllus* | Myrtaceae | Eugenol, Eugenyl acetate, caryophyllene | Used In spices essential oil and phenolic compounds |
| 16 | Eucalypt-us oil | *Eucalyptus globulus* | Myrtaceae | Cineole | Antiseptic, Antiviral, used in chronic bronchitis |
| 17 | Tea tree oil | *Melaleuca alternifolia* | Myrtaceae | Terpin-4-ol | Anti-fungal, anti-viral, |
| 18 | Jamun | *Syzygium cumini* | Myrtaceae | Anthocyanins, Pinene, flavonoids, terpinolene | Diabetes, inflammation, ulcer and diarrhoea. |
| 19 | Guava | *Psidium guajava* | Myrtaceae | Vitamin A, B, C, beta carotene, thiamine, phenolic compound etc. | Digestion, pain, diabetes, |
| 20 | Cajeput oil | *Melaleuca leucadendra* | Myrtaceae | 1,8-cineole (42-60%), α-terpineole (4-18%), caryophyllene (0.6-11%), and α-pinene (3-12%) | Antiseptic abilities. |
| 21 | Cinnamo-n | *Cinnamomum zeylanicum* | Lauraceae | Eugenol, cumin aldehyde | Antiseptic, pesticides, anti-diabetic, flavour |
| 22 | Bergam-ot oil | *Citrus bergamia* | Rutaceae | Monoterpenes, hydrocarbons, oxygenated monoterpenes and sesquiterpenes | antioxidant, anti-inflammatory, and cholesterol reducing functions. |
| 23 | Nimbu | *Citrus lemon* | Rutaceae | Vit C, Flavonoids (seriodictyol, hesperidin, naringin) | Skin infections, measles, smallpox. |
| 24 | Lemong-rass | *Cymbopogon citrates* | Poaceae | Terpenes, alcohol, ketones, aldehyde, citric etc. | Flavouring, fragrance, deodorant, soap, cosmetics and skin infection etc. |
| 25 | Fennel | *Foeniculum vulgare* | Apiaceae | Trans-anethole,2-pentanone | Digestion, Cough. |
| 26 | Eryngiu-m | *Eryngium maritimum.* | Apiaceae | terpenoids, saponins, flavonoids, coumarins, and steroids. | treating digestive problems, poisoning, tapeworms, bladder and kidney troubles, body soreness, etc. |
| 27 | Ashwaga-ndha | *Withania somnifera* | Solanaceae | Alkaloids is Withasomnine, Withanine, Anaferine. and Steroid is Withaferine- A | Sedative, tonic and aphrodisiac |

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| 28 | Kalmegh | *Andrographis paniculata* | Acanthaceae | diterpenoids, flavonoids and polyphenols. | anti-bacterial, anti-inflammatory and anti-cancer functions. |
| 29 | Moringa | *Moringa oleifera* | Moringacea-e | Niazirin and Niazirinin-nitrile glycosides,4-[(4′-O-acetylalpha- L-rhamnosyloxy) benzyl isothiocyanate, Niaziminin A, and Niaziminin B | Antioxidant, antiepileptic, anti-diabetic, CVD etc |
| 30 | Ritha | *Sapindus mukorossi*, | Sapindace-ae | saponins, genin, oleanolic acid, sopindic acid, sapindoside A & B | preventing hair fall and promotes hair growth, used to make soap and as a natural detergent. |
| 31 | Karanj | *Pongamia glabra* | Legumino-seae | Alkaloid, Steroid, Carbohydrate, Tannin, Flavonoids, Terpenoid, Coumarins, Phenol and Quinone. | its astringent and anti-inflammatory properties, improve gut motility and has a laxative property |
| 32 | Bougain-villea | *Bougainvillea glabra* | Nyctagina-cea | alkaloids, flavonoids, cardiac glycosides, saponines-3 and beta-cyanins-4. | anticancer, antihepatotoxic, anti-inflammatory, antihyperlipidemic, antimicrobial, antioxidant, and antiulcer properties |
| 33 | Marigol-d | *Calendula officinalis* | Asteraceae | limonene, terpinolene, (Z)- myroxide, piperitone, piperitenone, piperitenone oxide and b-caryophyllene | anti-inflammatory, antipyretic, antimicrobial, and antiepileptic effects |
| 34 | Chamo-mile | *Matricaria chamomilla* | Asteraceae | bisabolol, farnesene, chamazulene, apigenin, quercetin, patuletin, luteolin, and coumarin. | treat all kinds of diseases, including infections, neuropsychiatric, respiratory, gastrointestinal, and liver disorders |
| 35 | Burdock | *Arctium lappa L* | Asteraceae | Caeicacid, rutin, o-hydro benzoic acid, chlorogenic acid. Caffeic acid | Antioxidant properties, support digestive health, improves skin health. |
| 36 | Dandelio-on | *Taraxacum officinale* | Asteraceae | Taraxasterol, inulin | Liver health, digestive aid. |
| 37 | Chamo-mile | *Matricaria chamomilla* | Asteraceae | Bisabolol, chamazulene, apigenin | Treats infections, respiratory issues. |
| 38 | Gudmar | *Gymnema sylvestre* | Apocynac-eae | gymnemic acid, tartaric acid, gurmarin, calcium oxalate, glucose, stigmasterol, betaine, and choline | anti-diabetic action, anti-diuretic, antimicrobial, anti-obesity, Diuretics. |
| 39 | Bacopa | *Bacopa monnieri* | Plantaginac-eae | Bacosides, alkaloids | Cognitive enhancement, anti-anxiety. |
| 40 | Kalonji | *Nigella sativa* | Ranunculac-eae | Thymoquinone, carvacrol | Anti-inflammatory, antioxidant. |
| 41 | Hibiscus | *Hibiscus sabdariffa* | Malvaceae | Hibiscus acid, flavonoids | Antioxidant, blood pressure regulation. |
| 42 | Liquoric-e | *Glycyrrhiza glabra* | Fabaceae | Glycyrrhizin, flavonoids | Expectorant, anti-inflammatory. |
| 43 | Elderberr y | *Sambucus nigra* | Adoxaceae | Flavonoids, anthocyanins | Immune support, antioxidant. |
| 44 | Champa-ca | *Michelia champaca* | Magnoliace-ae | Sesquiterpene lactones, alkaloids, liridenine, terpenoids, steroids, [7,9] and polyphenols such as | diarrhoea, cough, bronchitis, hypertension, dyspepsia, fever, rheumatism, abscesses, dysmenorrhea and inflammation. |

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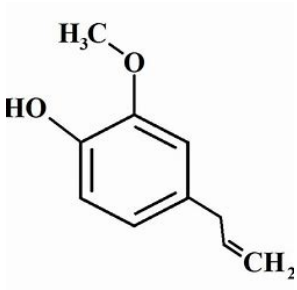
|---|---|---|---|---|---|
| | | | | rutin, quercetin and gallic acid | |
| 45 | Papaya | *Carica papaya* | Caricaceae | Vitamin A,B,C, proteolytic enzyme, isothiocyanate etc. | GIT disorders, sedative, diuretic etc. |
| 46 | Amerbel | *Cuscuta reflexa* | Convolvula-ceae | aporphine alkaloids, tannins, steroids, saponins, lignans, and mucilage. | vasorelaxant, aphrodisiac, anti-platelet aggregation, anti-cancer, anti-trypanosome, and antibacterial, anticonvulsant anti-hemorrhagic and diuretic activities. |
| 47 | Sandal wood | *Santalum albumlinn* | Santalaceae | Volatile oil, α-Santalola and β- santalol | Disinfectant, perfumery |
| 48 | Coriand-er | *Coriandrum sativum Linn* | Umbelliferae | Borneol, p-cymene, camphor, geraniol, limonene, and alpha-pinenes. | Aromatic, carminative, stimulant, alterative, antispasmodic, diaphoretic and flavouring agent |
| 49 | Primrose | *Primula vulgaris* | Primulaceae | Phenolic acids, flavonoids, sterols, hydrocarbons, and tocopherols. | Antioxidant, antimicrobial, anti-neuropathic, anti-inflammatory, anticancer and anti-ulcerogenic |
| 50 | Gokharu | *Tribulus terrestris* | Zygophyllac-eae | steroidal saponins, flavonoids, alkaloids, inorganic nitrate, carbohydrates, resins. | chest pain, heart problems, dizziness, skin and eye disorders, to expel kidney stones, and as a diuretic and tonic. |

**8.1.1 Phytochemistry of Commonly used Herbs**

This section examines the phytochemistry of frequently used herbs in sanitizers, emphasizing their primary chemical constituents known for antimicrobial activity. By highlighting these essential compounds, we can gain insights into how these natural ingredients enhance the efficacy of sanitizers against pathogens. [24-32]

**Table No.2: Phytoconstituents Exhibiting Antibacterial Properties**

| Sr no. | Herbs | Name of Active Constituent | Chemical Structure | Properties | Reference |
|---|---|---|---|---|---|
| 1 | Clove | Eugenol (80-90%) |  | Effective against Gram +ve & Gram-ve bacteria. | [24,31,32] |

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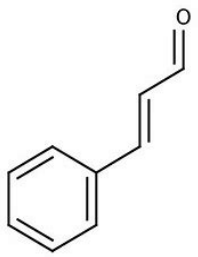
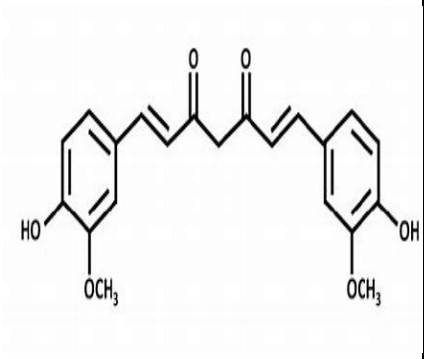
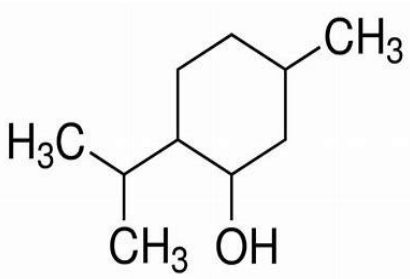
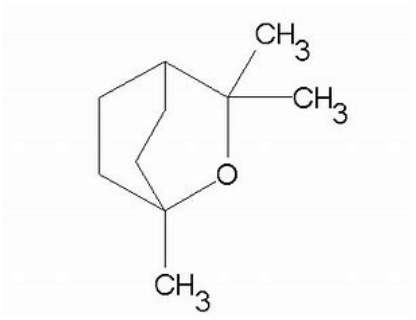
|---|---|---|---|---|---|
| 2 | Cinnamon | Cinnamaldehyde (60-70%) |  | Strong Antimicrobial activity against various bacteria. | [24,31,32] |
| 3 | Turmeric | Curcumin (2-5%) |  | Potent Antibacterial & Anti-inflammatory compound. | [31,41,32] |
| 4 | Mint | Menthol (35-45%) |  | Antibacterial activity against oral pathogens. | [24,31,32] |
| 5 | Eucalyptus | Eucalyptol (70-80%) |  | Antimicrobial properties against Respiratory pathogens. | [24,31,32] |

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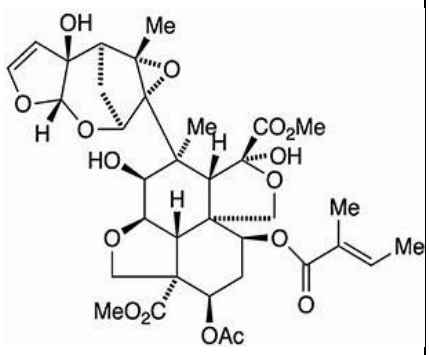
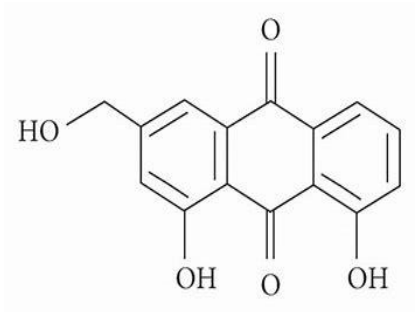
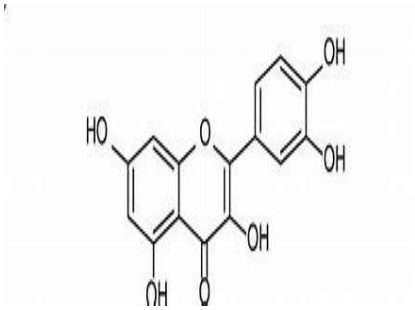
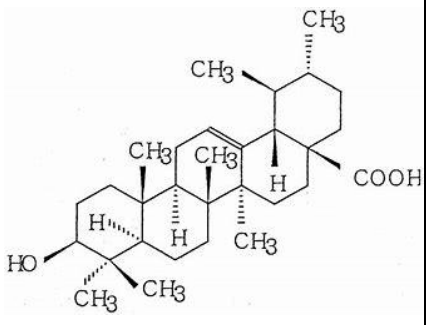
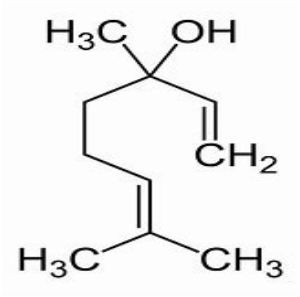
| | | | | | |
|---|---|---|---|---|---|
| 6 | Neem | Azadirachtin (0.5-1.5%) |  | Exhibits broad spectrum Antibacterial & Antifungal activity. | [27,32] |
| 7 | Aloe vera | Aloe emodin |  | Antibacterial activity against various bacteria. | [27,32] |
| 8 | Guava | Quercetin |  | Antibacterial activity against Food-borne pathogens. | [26,27,30] |
| 9 | Tulsi | Ursolic acid |  | Antibacterial activity against various bacteria. | [28,29,32] |

| | | | | | |
|---|---|---|---|---|---|
| 10 | Lavender oil | Linalool |  | Antibacterial activity against skin pathogens. | [24,32] |

**8.1.2 Extraction method**

In this section, we summarize various extraction methods from existing research studies, detailing the solvents used to extract herbal ingredients for sanitizer formulations.

**Table No.3: Optimised Extraction Methods for Herbal Sanitizer Phytoconstituents.**

| Herbs | Extraction Method | Solvent | Phytoconstituents Responsible for Antimicrobial Activity | Reference |
|---|---|---|---|---|
| 1. Drum Stick | Maceration | Methanol | Isothiocyanates, Glucosinolates, Flavonoids. | [33] |
| 2. Neem | Soxhlet, Maceration, Infusion. | Water, Methanol, Ethanol | Limonoids, Azadirachtin, Nimbolide, | [34-37] |
| 3. Tulsi | Soxhlet, Maceration, Infusion | Water, Methanol, Ethanol. | Linoleic Acid, Eucalptol, Eugenol, B-Caryophyllene, Cirsilineol, Circimaritin, Isothymusin, Apigenin. | [1,23] [34-42] |
| 4. Lemon | Soxhlet | Water, Ethanol | Saponin, Terpenoids, Limonene, Sabinene, Careen, B-Ocimene. | [34,38,42] |
| 5. Liquorice | Soxhlet | N-Hexane | Glycyrrhizin, Liquiritin, Glabridin. | [35] |
| 6. Shatavari | Soxhlet | N-Hexane | Shatavarin, Aasparacosides, Racemosol, Asparagamine, Pyrrolizidine Alkaloid. | [35] |
| 7. Ashwagandha | Soxhlet | N-Hexane | Withanolides (Withanolide D, Withaferine A) | [35] |
| 8. Indian Sarsaparilla | Soxhlet | N-Hexane | Tannin, Saponin, Lupeol Octocosonoate, B-Sitosterol. | [35] |
| 9. Nilgiri | Infusion, Maceration, Hydro-Distillation | Ethanol, Methanol, Water | Limonene, P-Cymene, 1,8-Cineole, Citronellal, Isopulegol. | [37] |
| 10. Amerbel | Maceration | Ethanol | Alkaloids, Saponins | [37] |
| 11. Alovera | Maceration | Ethanol | Emodin, Aloe-Emodin, P- Coumaric Acid, Ascorbic Acid, Pyrocatechol, Cinnamic Acid. | [37] |
| 12. Mint | Maceration | Ethanol | Menthol, Monoterpenoids, Methofuran, Menthyl Acetate. | [37] |
| 13. Pomegranate | Soxhlet | Ehanol | Punicalagin, Ellagic Acid, Gallotannins | [38] |
| 14. Sweet Lime | Soxhlet | Ethanol | Limonene | [38] |

| | | | | |
|---|---|---|---|---|
| 15. Guava | Maceration Decoction | Ethanol, Methanol, Water | Guavins A-D, Quercetin, B-Caryophylllene, Psidinone. | [26-27] |
| 16. Turmeric | Maceration | Ethanol | Curcumin | [41] |
| 17. Coriander | Infusion | Ehanol | Decanol, Dodecanal, B-Linalool. | [42] |
| 18. Clove | Infusion | Ethanol | Eugenol, Carvacrol. | [42] |
| 19. Lemon Grass | Infusion, Hydro Distillation Method | Ehanol Water. | Citral, Geraniol. | [42] |
| 20. Cinnamon | Infusion | Ehanol | Cinnamaldehyde, Eugenol. | [42] |
| 21. Orange | Percolation | Ethanol, | Limonene, Sinesis, Linalool, Eugenol. | [44] |

**8.2. Excipients** [45,46]

**a. Solvents**

- **Ethanol:** Effective at 60-80% concentration for killing germs; also a great solvent for herbal extracts.
- **Isopropyl Alcohol:** Typically used at around 70% concentration; effective and widely available.
- **Witch Hazel:** A natural astringent with mild antimicrobial properties, useful as a solvent and skin soother.
- **Vegetable Glycerides:** Retains moisture and works well with herbal extracts, enhancing skin feel.
- **Floral Waters (e.g., Rosewater):** Gentle and aromatic, providing soothing properties while acting as a solvent.
- **Coconut Oil:** Provides moisturizing benefits and has some antimicrobial properties; can help extract herbal compounds.
- **Jojoba Oil:** Mimics natural skin oils and provides moisture without greasiness.
- **Distilled Water:** Used to dilute alcohol or herbal extracts, ensuring purity and reducing irritation.

**b. Thickening Agents**

- **Xanthan Gum:** A natural polysaccharide that thickens and stabilizes formulations, enhancing texture and preventing ingredient separation.
- **Guar Gum:** Derived from guar seeds, this thickener offers high water-binding capacity, smooth texture, and acts as a stabilizer for improved shelf life.
- **Agar-Agar:** Extracted from red algae, it provides thickening and gelling properties, making it a natural alternative for a firm texture.
- **Carbomer:** A synthetic polymer known for exceptional thickening abilities, creating a luxurious gel-like feel and stabilizing emulsions.
- **Sodium Alginate:** Sourced from brown seaweed, it enhances viscosity and provides a smooth application experience in eco-friendly products.
- **Cellulose Derivative:** Plant-based thickeners like HPMC and CMC improve viscosity and stability, ensuring consistent formulations.
- **Pectin:** A natural carbohydrate from fruits that thickens and enhances texture, appealing to consumers seeking clean-label products.

➢ **Aloe Vera Gel:** Renowned for its soothing and moisturizing properties, it adds thickness and is suitable for sensitive skin, enhancing the overall user experience.

**c. Preservatives**

➢ **Vitamin E (Tocopherol):** A natural antioxidant that helps prevent the oxidation of oils and extends the shelf life of products. It also offers skin benefits.

➢ **Rosemary Extract:** Known for its antimicrobial properties, rosemary extract can act as a natural preservative while also providing a pleasant aroma.

➢ **Grapefruit Seed Extract:** This extract has antimicrobial properties and can help inhibit the growth of bacteria and fungi, making it a popular choice for natural formulations.

➢ **Potassium Sorbate:** A widely used preservative that inhibits the growth of mold and yeast, it's considered safe and effective in many cosmetic products.

➢ **Sodium Benzoate:** Commonly used in food and cosmetic products, it helps to prevent the growth of bacteria, yeast, and fungi.

➢ **Phenoxyethanol:** A synthetic preservative often used in cosmetics and personal care products to prevent microbial growth. It is effective at low concentrations.

➢ **Ethanol:** While primarily an active ingredient for sanitization, ethanol can also have preservative effects due to its antimicrobial properties.

➢ **Coconut Oil:** In some formulations, the natural fatty acids in coconut oil can help provide mild antimicrobial effects, contributing to preservation.

**d. Colorants**

➢ **Natural Plant Extracts:** Extracts from herbs, flowers, or fruits can provide colour and may also offer additional skin benefits. Examples include beetroot powder (for red), turmeric (for yellow), and spirulina (for green).

➢ **Curcumin:** A natural pigment derived from turmeric, curcumin imparts a vibrant yellow colour and has anti-inflammatory properties.

➢ **Chlorophyll:** Extracted from green plants, chlorophyll adds a natural green hue and can have antioxidant benefits.

➢ **Caramel Colour:** Made from the heating of sugars, caramel colour is often used to provide a brown hue without affecting the product's safety.

➢ **Paprika Extract:** This extract provides a red to orange colour and is derived from ground paprika peppers, adding both colour and potential antioxidant benefits.

➢ **Beet Juice Powder:** A natural colorant that provides a rich red hue, beet juice powder also offers nutritional benefits.

➢ **Annatto Extract:** Sourced from the seeds of the achiote tree, this natural colorant provides a yellow to orange colour and is often used in food and cosmetics.

➢ **Titanium Dioxide:** While primarily a white pigment and opacifier, it can be used to lighten other colours in formulations.

**e. Fragrant**

➢ **Tea Tree Oil:** Renowned for its strong antibacterial and antiviral properties, making it effective against a variety of pathogens.

➢ **Lavender Oil**: Offers a soothing, calming scent and possesses antimicrobial benefits, promoting relaxation.

➢ **Eucalyptus Oil:** Features a refreshing aroma with notable antiseptic properties, ideal for a clean, invigorating scent.

➢ **Peppermint Oil:** Delivers a cool, refreshing scent while providing antimicrobial effects, enhancing the sanitizer's overall efficacy.

➢ **Lemon Oil:** Known for its bright, citrusy fragrance, it also has natural antibacterial properties that help fight germs.

➢ **Rosemary Oil:** Imparts an herbaceous scent along with antioxidant and antimicrobial properties, adding depth to the formulation.

**9. Types of Herbal Sanitizer.** [47-51]

**A. Herbal Alcohol-Based Sanitizers**

❖ **Definition**

Herbal alcohol-based sanitizers are hand sanitizers that contain a significant percentage (typically 60-70%) of alcohol (ethanol or isopropyl) as the primary active ingredient, supplemented with herbal extracts and essential oils that provide additional antimicrobial benefits and pleasant fragrances.

❖ **Classification**

**a. Based on Alcohol Type:**

➢ **Ethanol-based:** Uses ethanol as the active ingredient.

➢ **Isopropyl-based:** Uses isopropyl alcohol.

**b. Based on Herbal Additives:**

➢ **Essential Oil-infused:** Contains essential oils like tea tree, lavender, or eucalyptus.

➢ **Botanical Extracts:** Includes extracts from plants known for their antimicrobial properties, like aloe vera.

❖ **Advantages**

➢ **Effective Against Pathogens:** Quickly kills bacteria, viruses, and fungi.

➢ **Rapid Action:** Starts working almost immediately upon application.

➢ **Pleasant Fragrance:** Herbal additives can enhance the sensory experience.

➢ **Convenience:** Portable and easy to use, making them ideal for on-the-go situations.

❖ **Disadvantages**

➢ **Skin Irritation**: Frequent use can lead to dryness and irritation, especially for sensitive skin.

➢ **Flammability:** High alcohol content makes these products flammable.

➢ **Ineffective on Dirt:** Does not remove physical dirt, which can harbour pathogens.

➢ **Limited Shelf Life:** May degrade over time, especially if not stored properly

**B. Herbal Non-Alcohol-Based Sanitizers**

❖ **Definition**

Herbal non-alcohol-based sanitizers are hand sanitizers that do not contain alcohol but instead use natural ingredients, including herbal extracts and essential oils, to provide antimicrobial effects. They often include natural surfactants and moisturizers.

❖ **Classification**

**a. Based on Active Ingredients:**

- **Herbal Extracts:** Includes extracts from plants like aloe vera, neem, or witch hazel.
- **Essential Oils:** May incorporate oils known for their antimicrobial properties, such as tea tree or peppermint.

**b. Based on Formulation:**

- **Gel-based:** Often formulated as a gel for easy application.
- **Liquid-based:** Available in a liquid form, suitable for use with dispensers.

❖ **Advantages**

- **Gentler on Skin:** Typically, less drying and irritating, making them suitable for sensitive skin.
- **Natural Ingredients:** Appeals to consumers seeking chemical-free products.
- **Moisturizing Properties:** Many contain ingredients that help hydrate the skin.
- **Environmental Appeal:** Often considered more sustainable and eco-friendly.

❖ **Disadvantages**

- **Variable Efficacy:** May not be as effective against certain pathogens, especially viruses.
- **Shorter Shelf Life:** Natural ingredients may degrade faster, necessitating more frequent replacements.
- **Complementary Role:** Often better suited for routine hand hygiene rather than high-risk sanitization needs.
- **Potential Allergens:** Some individuals may have allergies or sensitivities to specific herbal ingredients.

Both herbal alcohol-based and non-alcohol-based sanitizers have their unique roles in hygiene practices. Alcohol-based sanitizers offer rapid and broad-spectrum antimicrobial action, while non-alcohol options provide gentler, more moisturizing alternatives.

**10. Mechanism of Antibacterial action of Herbal ingredients in Sanitizer**

This overview explores the antibacterial mechanisms of herbal sanitizer components, including alcohol, essential oils, glycerol, and polyphenols. These ingredients work together to effectively combat pathogens, making herbal sanitizers a viable option for hygiene.

**A. Alcohol**

Alcohol exhibits antibacterial properties by denaturing and coagulating the proteins found in bacteria. This disrupts cellular metabolism, ultimately leading to the lysis of the microorganism's cells. The effects of alcohol are rapid and wide-ranging. However, at higher concentrations, its effectiveness decreases because water is necessary for breaking down the bacterial cell wall. [2]

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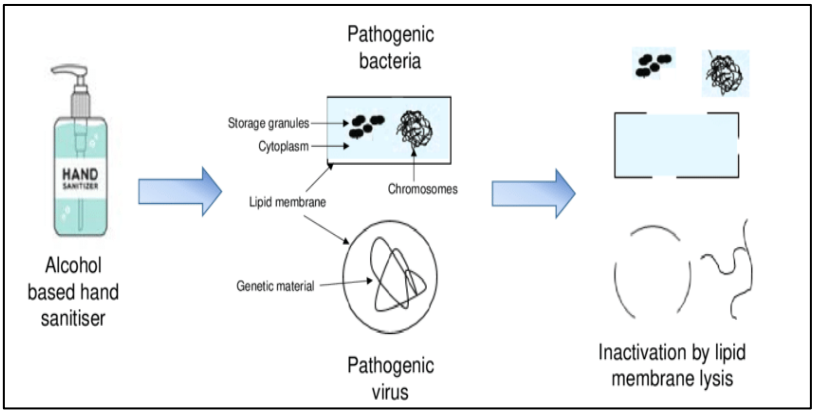


**Fig. 2: Mechanism of Antibacterial Action of Alcohol**.

### B. Polyphenols

Polyphenols exert antibacterial action through several mechanisms. They can disrupt bacterial cell membranes, leading to increased permeability and leakage of vital intracellular components. Additionally, polyphenols can inhibit essential enzymes and interfere with metabolic pathways, hindering bacterial growth and reproduction. Their ability to scavenge reactive oxygen species also induces oxidative stress in bacterial cells, causing damage to proteins, lipids, and DNA. Furthermore, polyphenols can modulate bacterial signalling pathways, disrupting communication within bacterial communities, which contributes to their overall antimicrobial effectiveness. [2]

### C. Essential Oils

Essential oils exert antibacterial action through multiple mechanisms. They disrupt bacterial cell membranes, increasing permeability and causing leakage of vital components, leading to cell death. Additionally, they can denature proteins, inhibit enzyme activity, and interfere with DNA/RNA synthesis, impairing bacterial growth and function. Some essential oils also generate reactive oxygen species, inducing oxidative stress that damages cellular structures. Overall, the effectiveness of essential oils varies depending on their composition, concentration, and the specific bacterial strain targeted. [20,28]

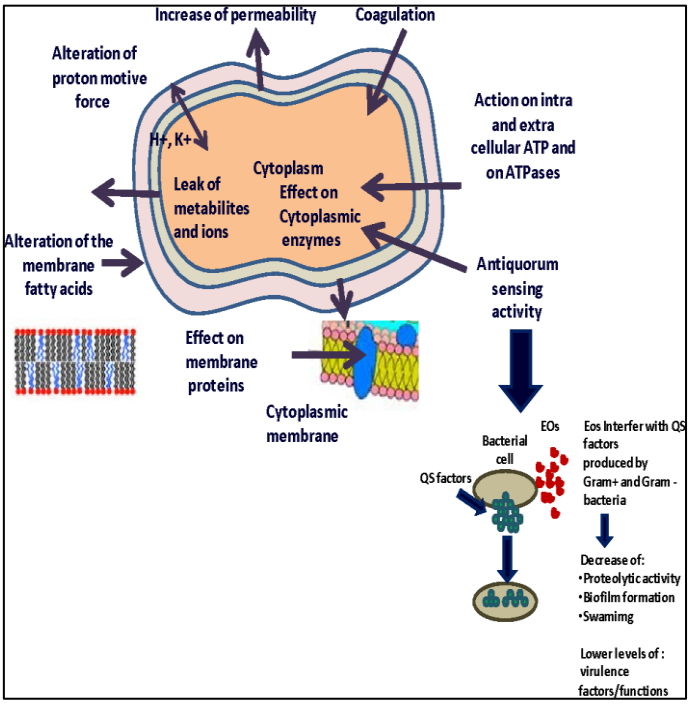


**Fig. 3: Mechanism of Antibacterial action of Essential Oils.**

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**D. Glycerol (Monoglycerides)**

Monoglycerides exert antibacterial action primarily by disrupting bacterial cell membranes. They incorporate themselves into the lipid bilayer, leading to increased permeability and leakage of essential cellular components, which can result in cell lysis. Additionally, monoglycerides can inhibit enzymatic activity and interfere with nutrient transport, impairing bacterial metabolism and growth. Their amphiphilic nature allows them to interact with both hydrophobic and hydrophilic regions of bacterial cells, enhancing their antimicrobial effectiveness against various strains. [2]

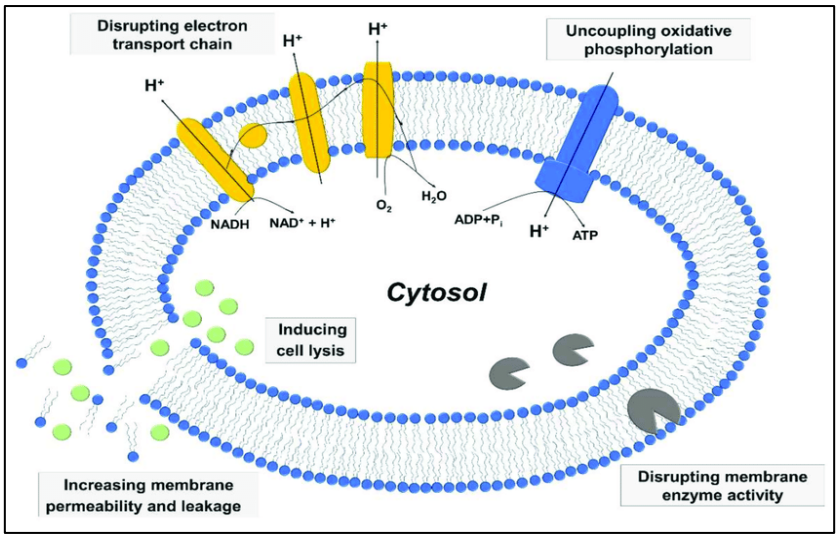


**Fig. 4: Mechanism of Antibacterial Action of Glycerol.**

**11. Method of Preparation of Herbal Sanitizers** [50]

This guide outlines the method for preparing herbal sanitizers, detailing the step-by-step process involved in creating effective formulations.

❖ **Direct Addition Method**

1. Mix alcohol and water.
2. Dissolve soluble ingredients.
3. Gradually add thickener (sifting) to the mixture, agitating vigorously.
4. Add pH adjuster (if needed) to reach pH 6.5-7.

❖ **Reverse Addition Method**

1. Prepare thickener slurry in glycerol/propylene glycol.
2. Mix alcohol, water, and soluble ingredients.
3. Gradually add hydroalcoholic solution to thickener slurry, stirring vigorously.
4. Add pH adjuster (if needed) to reach pH 6.5-7.

❖ **Modified Hot/Cold Method (HPC/HPMC)**

1. Dissolve non-volatile ingredients in hot water.

2. Gradually add thickener, agitating vigorously.
3. Stop heating.
4. Add alcohol while cooling.

❖ **Hybrid Direct/Reverse Addition Method**

1. Prepare thickener slurry in glycerol/propylene glycol.
2. Mix alcohol, water, and soluble ingredients.
3. Gradually add slurry to hydroalcoholic solution, agitating.
4. Add pH adjuster (if needed, for carbomers) to reach pH 6.5-7

Glycerol and propylene glycol serve as wetting agents and emollients in these methods

## 12. Evaluation Parameters

In the quest to develop effective herbal sanitizers, researchers have conducted a series of evaluation tests to assess the formulation's efficacy and safety. Central to this investigation are the dosage form tests, which ensure that the herbal ingredients are delivered in a suitable and effective manner. Additionally, the determination of biological activity plays a crucial role in evaluating the sanitizers' potential to inhibit microbial growth. Through these assessments, the researchers aim to validate the therapeutic potential of herbal sanitizers and contribute to the growing body of knowledge in natural product formulations.

❖ **Evaluation of Dosage form**

### A. Organoleptic Test

The formulation undergoes visual inspection to assess texture, odour, and colour under semisolid conditions. [39,51]

### B. pH Evaluation

The pH of the formulations is measured using a digital pH meter. Results are presented as the mean ± standard deviation (SD) based on multiple replicates. [39,51]

### C. Viscosity (Rheological Properties)

The rheological properties of the formulations are determined at room temperature using a viscometer. A suitable piston range is selected based on the formulation texture, and measurements are taken after allowing the system to stabilize. Results are reported as the mean ± SD from multiple replicates. [39,51]

### D. Formulation Spreadability

The spreadability of the hand sanitizers is assessed by applying a sample to a pre-marked surface and then applying a weight to measure the slip and drag characteristics. Excess formulation is removed from the edges for accurate measurement. [39,51]

❖ **Biological Evaluation**

### E. Antimicrobial Zone of Inhibition Test

The antimicrobial activity of the formulation is evaluated by measuring the zone of inhibition against various bacterial and yeast strains. A control group of commercially available hand sanitizers is included. An inoculum is evenly distributed on agar plates, and samples are applied using sterile discs. Plates are incubated, and the inhibition zones are measured, with results reported as the mean ± SD from multiple replicates. [34]

### F. Skin Irritation Study (Acceptability Test)

The most effective formulation undergoes a skin irritation study with volunteers. Ethical approval is obtained, and consent is secured before applying the formulation to participants' palms for a specified duration to observe any adverse reactions. [34]

### G. DPPH Assay

The DPPH assay is a method used to evaluate the antioxidant activity of herbal sanitizers. The procedure begins with the preparation of a DPPH solution in an appropriate solvent. Next, the herbal sanitizer sample is diluted in a suitable solvent. The two solutions are then combined in a cuvette. After mixing, the sample is allowed to incubate for a specified period while being protected from light, which can degrade DPPH. Following the incubation, the absorbance of the mixture is measured using a spectrophotometer. The percentage of DPPH scavenging activity is calculated based on the absorbance values obtained. Finally, the results are analysed to assess the antioxidant potential of the herbal sanitizer. This method provides valuable insights into the effectiveness of the sanitizer in neutralizing free radicals. [34]

## 13. Conclusion

In conclusion, the classification of sanitization techniques reveals a rising interest in herbal alternatives to chemical sanitizers, due to their natural composition and lower side effects. Sanitizers can be divided into chemical and herbal categories, with herbal options gaining momentum. Among 50 analyzed herbs, 7 belong to the Myrtaceae family, 6 to Lamiaceae, and 5 to Asteraceae, with Myrtaceae showing notable antibacterial properties. This suggests that other herbs within this family may also have similar potential. Further research into these herbs could enhance herbal sanitizer formulations. Various phytochemical studies and extraction methods support their efficacy in natural sanitization.

## 14. Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this review article.

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