

A Comprehensive Review on Antiseptic Gel

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Abstract—Herbal antiseptic gels have gained increasing attention as natural alternatives to conventional synthetic antiseptics due to rising concerns about skin irritation, microbiome disruption, and long-term safety associated with repeated use of chemical disinfectants. These gels are formulated using medicinal plant extracts and essential oils rich in bioactive phytochemicals such as flavonoids, phenolics, tannins, alkaloids, terpenoids, and saponins, which collectively provide broad-spectrum antimicrobial, anti-inflammatory, antioxidant, and wound-healing effects. Commonly used botanicals include Aloe vera, *Azadirachta indica* (neem), *Curcuma longa* (turmeric), tea tree oil, garlic, ginger, lemongrass, and guava leaves, each contributing unique mechanisms of action against bacteria, fungi, and certain viruses. Herbal antiseptic gels offer several advantages over synthetic formulations, including improved skin compatibility, reduced irritation, lower risk of antimicrobial resistance due to multi-target activity, and environmental friendliness. Their gel-based nature, achieved using natural or synthetic polymers such as aloe gel, xanthan gum, carbopol, or HPMC, ensures ease of application, good spreadability, and user acceptability. These formulations are classified based on active herbal ingredients, extraction methods, antimicrobial mechanisms, gelling agents, and therapeutic applications, ranging from routine hand hygiene and wound care to acne management and cosmetic use. Understanding skin anatomy and physiology is essential for evaluating the safety and effectiveness of these gels, as most act on the epidermal surface while supporting barrier integrity and wound healing. Preparation methods involve careful extraction, formulation, pH adjustment, and evaluation to ensure stability and efficacy. Overall, literature evidence supports herbal antiseptic gels as effective, safe, and versatile topical agents, though challenges such as standardization, stability, and large-scale clinical validation remain for future research.

Keywords—Antiseptic gel, Topical antiseptic formulations, Herbal antiseptic gel, Synthetic antiseptic gel, Hand sanitizer gels, Antimicrobial gel formulations, Topical antimicrobial agents

I. INTRODUCTION

Herbal antiseptic gels have emerged as important alternatives to conventional synthetic antiseptic formulations, driven by increasing interest in natural products, improved skin compatibility, and concerns about the side effects associated with repeated use of chemical disinfectants. Traditional antiseptic gels, especially those containing alcohol, chlorhexidine, or quaternary ammonium compounds, are highly effective but may cause adverse reactions such as skin dryness, irritation, and disruption of the natural skin microbiome. As a result, there is a growing demand for herbal-based antiseptic gels formulated from plant-derived extracts and essential oils with proven antimicrobial and soothing properties.

Medicinal plants have a long history of use in treating skin infections and supporting wound healing due to their rich contents of bioactive compounds such as alkaloids, flavonoids, tannins, terpenoids, phenolics, and saponins. These phytochemicals possess broad-spectrum antimicrobial, anti-inflammatory, antioxidant, and wound-healing activities, making them suitable active ingredients for topical antiseptic formulations. Commonly used plants in herbal antiseptic gels include Aloe vera, neem (*Azadirachta indica*), tea tree (*Melaleuca alternifolia*), turmeric (*Curcuma longa*), guava (*Psidium guajava*), garlic (*Allium sativum*), ginger (*Zingiber officinale*), and lemongrass (*Cymbopogon citratus*), each offering unique mechanisms of action against pathogenic microorganisms.

Herbal antiseptic gels also appeal to consumers due to their potential for enhanced skin compatibility. Many plant extracts possess natural moisturizing, cooling, and emollient effects that help maintain the skin barrier, reduce irritation, and improve user compliance. In addition, due to their gel-based formulation using natural polymers such as xanthan gum, carbopol, or aloe gel matrix, herbal antiseptic gels offer ease of application, rapid absorption, and non-greasy feel, making them suitable for routine personal hygiene and minor wound care.

Global interest in herbal antiseptic products has further increased following recent public health concerns and infectious disease outbreaks, which highlighted the importance of effective and accessible hand hygiene products. While alcohol-based sanitizers remain essential in healthcare settings, herbal gels provide an attractive alternative for long-term community use, especially where gentler and environmentally friendly products are preferred

II. ADVANTAGES OF HERBAL ANTISEPTIC GEL

2.1. Broad-Spectrum Antimicrobial Activity

Many medicinal plants contain multiple bioactive compounds—such as alkaloids, phenolics, flavonoids, tannins, terpenoids, and saponins—that exhibit strong antimicrobial effects. Unlike synthetic antiseptics, which often rely on a single active chemical, herbal antiseptic gels have multi-compound, multi-target antimicrobial action that enhances their ability to inhibit:

- Gram-positive and Gram-negative bacteria
- Some fungi and yeasts
- Certain viruses
- Dermatophytes and wound pathogens

2.2. Reduced Skin Irritation and Improved Skin Compatibility

One of the major advantages of herbal antiseptic gels is their superior skin tolerability. Many plant extracts possess natural skin-soothing, moisturizing, and anti-inflammatory properties. Ingredients such as Aloe vera, neem, chamomile, green tea, or coconut oil help to:

- Reduce redness and irritation
- Maintain skin hydration
- Restore the skin's protective barrier
- Minimize allergic reactions compared to alcohol or chlorhexidine

2.3. Multiple Therapeutic Benefits Beyond Antimicrobial Action

Many herbal extracts used in antiseptic gels provide additional therapeutic benefits, making them ideal for minor cuts, abrasions, and skin infections. These benefits include:

- Anti-inflammatory activity: reducing swelling and redness
- Antioxidant activity: protecting skin cells from free radical damage

Wound-healing properties: enhancing re-epithelialization and collagen synthesis
Analgesic effects: reducing discomfort around irritated skin

2.4. Lower Risk of Antimicrobial Resistance

Synthetic antiseptics with single active ingredients may contribute to microbial adaptation and resistance. Herbal antiseptic gels contain a combination of phytochemicals that act on multiple cellular targets, such as:

- Cell membrane disruption
- Protein denaturation
- Enzyme inhibition
- DNA interference

2.5. Environmental Friendliness and Biodegradability

Herbal antiseptic gels often use plant-derived ingredients and natural polymers, making them more environmentally friendly than synthetic formulations. Their advantages include:

- Biodegradation without harmful residues
- Reduced chemical pollution
- Sustainable sourcing of plant materials
- Lower ecological footprint during production

2.6. Enhanced Consumer Acceptability

Consumers increasingly prefer natural and herbal products due to heightened awareness of health and chemical exposure.

- Natural fragrances and colors
- Pleasant textures
- Mild, non-alcoholic or low-alcohol formulations
- Botanical branding that improves user trust

III. CLASSIFICATION OF HERBAL ANTISEPTIC GELS

3.1. Classification Based on Active Herbal Ingredient
Herbal antiseptic gels may contain a single plant extract or a combination of two or more synergistic extracts. Common categories include:

3.1.1. Aloe Vera-Based Gels

Contain Aloe vera mucilage rich in polysaccharides, anthraquinones, and glycoproteins.
Functions: antimicrobial, anti-inflammatory, moisturizing, wound healing.

3.1.2. Neem-Based Gels (*Azadirachta indica*)

Neem contains azadirachtin, nimbin, and quercetin.

Functions: strong antibacterial, antifungal, antiviral, anti-inflammatory.

3.1.3. Tea Tree Oil-Based Gels (*Melaleuca alternifolia*)

Rich in terpinen-4-ol and cineole.

Functions: broad-spectrum antimicrobial, antiseptic, and anti-inflammatory.

3.1.4. Turmeric-Based Gels (*Curcuma longa*)

Contains curcumin, a potent antioxidant and antimicrobial compound.

Functions: wound healing, antibacterial, anti-inflammatory.

3.1.5. Guava Leaf-Based Gels (*Psidium guajava*)

Rich in tannins and flavonoids.

Functions: antibacterial, antioxidant, astringent.

3.1.6. Ginger or Garlic Extract Gels

Ginger contains gingerol; garlic contains allicin.

Functions: strong antimicrobial and anti-inflammatory activity.

3.1.7. Lemongrass or Citrus Oil-Based Gels

Contain citral and limonene.

Functions: antibacterial, antifungal, pleasant fragrance.

3.2. Classification Based on Type of Plant Extract

The extraction method affects the potency and stability of herbal antiseptic gels.

3.2.1. Aqueous Extract-Based Gels

Use water as the solvent, suitable for polar phytochemicals such as tannins and flavonoids.

3.2.2. Ethanolic or Hydro-Alcoholic Extract Gels

Extract a broader range of bioactive compounds, including alkaloids and terpenoids, enhancing antimicrobial potency.

3.3. Classification Based on Mechanism of Antimicrobial Action

Herbal antiseptic gels can be grouped according to how their phytochemicals inhibit microorganisms.

3.3.1. Cell Membrane Disruptors

Essential oils (e.g., tea tree, lemongrass) disrupt microbial membranes, causing leakage of cellular contents.

3.3.2. Enzyme Inhibitors

Certain plant compounds (e.g., curcumin, allicin) inhibit microbial enzymes essential for metabolism.

3.3.3. DNA or Protein Synthesis Inhibitors

Compounds such as flavonoids and phenolics interfere with microbial replication and protein synthesis.

3.3.4. Antioxidants with Antimicrobial Effect

Polyphenols from herbs like green tea or guava produce oxidative stress that kills bacteria.

3.4. Classification Based on Formulation Base or Gelling Agent

Gels differ depending on the type of gelling agent used.

3.4.1. Natural Polymer Gels

Include: Aloe vera gel matrix, Xanthan gum, Guar gum, Pectin

3.4.2. Synthetic Polymer Gels

Such as: Carbopol, Hydroxypropyl methylcellulose (HPMC)
Polyvinyl alcohol (PVA)

3.5. Classification Based on Therapeutic Application

Herbal antiseptic gels can be designed for specific uses:

3.5.1. General Hand Hygiene Gels

Contain mild herbal extracts suitable for daily use.

3.5.2. Wound Care Antiseptic Gels

Formulated with extracts that support tissue repair, such as aloe vera and turmeric.

3.5.3. Anti-Acne or Skin Infection Gels

Use antimicrobial plants like tea tree oil or neem to target acne-causing bacteria.

3.5.4. Pediatric and Sensitive Skin Gels

Feature gentle plant ingredients, low fragrance, and hypoallergenic formulations

3.5.5. Multi-Herbal Combination Gels

Utilize synergistic blends—such as neem + turmeric or aloe + tea tree—to enhance antimicrobial and healing properties.

IV. ANATOMY AND PHYSIOLOGY (Relevance to Herbal Antiseptic Gel Use)

Understanding the anatomy and physiology of the skin is essential when evaluating the effectiveness and safety of herbal antiseptic gels. The skin acts as the first line of defense against microbial invasion, chemical exposure, and environmental damage. Herbal antiseptic gels are designed to interact with the outer layers of the skin, enhance its protective functions, and prevent colonization by pathogenic microorganisms. This section provides an overview of the structure and function of the skin, emphasizing aspects that are directly relevant to the penetration, absorption, and antimicrobial action of herbal antiseptic gels.

4.1. Overview of the Skin

The skin is the largest organ of the human body and serves as a physical, chemical, and immunological barrier. It is composed of three main layers:

1. Epidermis
2. Dermis
3. Hypodermis (subcutaneous layer)

Each of these layers plays a specific role in protecting the body and influencing the performance of topical antiseptic formulations.

4.2. The Epidermis

The epidermis is the outermost layer and the primary site where antiseptic gels exert their action.

4.2.1. Stratum Corneum

The uppermost sublayer of the epidermis, composed of dead, keratinized cells embedded in a lipid matrix.

Relevance to antiseptic gels:

It forms a barrier that limits penetration of harmful substances.

Herbal antiseptic gels must act at this surface level without causing irritation or dryness.

Natural extracts like aloe vera and glycerin help maintain moisture and prevent barrier disruption.

4.2.2. Epidermal Renewal

The epidermis undergoes continuous cell turnover, typically every 28–30 days.

Herbal antiseptic gels with soothing or antioxidant ingredients may support this regeneration process.

4.2.3. Microbial Flora on the Epidermis

The skin hosts beneficial bacteria forming a natural microbiome.

Herbal antiseptics aim to reduce pathogenic microbes without excessively disturbing beneficial flora.

4.3. The Dermis

Located beneath the epidermis, the dermis contains connective tissue, blood vessels, nerves, and skin appendages.

4.3.1. Blood Supply and Absorption

Although antiseptic gels mainly act on the surface, the dermal blood supply can influence systemic absorption if compounds penetrate deeper.

Herbal formulations generally have low systemic absorption, reducing toxicity risks.

4.3.2. Role in Wound Healing

The dermis plays a central role in tissue repair through fibroblast activity and collagen production. Herbal extracts such as aloe vera, turmeric, neem, and tea tree oil support dermal healing by:

Reducing inflammation

Enhancing collagen synthesis

Promoting angiogenesis

Thus, herbal antiseptic gels can aid in minor wound management

4.4. The Hypodermis (Subcutaneous Layer)

This layer consists mainly of fat and connective tissue. It serves as insulation and shock absorption.

Herbal gels typically do not reach this layer, but understanding its role is important for assessing product safety.

4.5. Skin Appendages and Their Importance

4.5.1. Sweat Glands

Secrete sweat and maintain moisture.

Some herbal antiseptic gels help regulate microbial activity in sweat-filled environments.

4.5.2. Sebaceous Glands

Produce sebum that protects skin but can also harbor bacteria like *Staphylococcus aureus*.

Herbal extracts such as neem and tea tree oil help control microbial buildup in oily regions.

4.5.3. Hair Follicles

Serve as reservoirs for microbes.

Essential oils can penetrate follicular openings better than synthetic agents due to lipophilic properties.

V. MECHANISM OF ACTION OF HERBAL ANTISEPTIC GELS

The mechanism of action of herbal antiseptic gels is primarily attributed to the diverse array of

phytochemicals present in medicinal plants. These bioactive compounds act individually or synergistically to inhibit or kill pathogenic microorganisms through multiple biological pathways. Unlike synthetic antiseptics that often rely on a single active chemical, herbal antiseptics contain complex mixtures of phenolics, terpenoids, flavonoids, alkaloids, and other natural constituents that target several microbial structures and metabolic processes simultaneously. This multi-target approach contributes to broad-spectrum activity and reduces the risk of antimicrobial resistance.

Herbal antiseptic gels exert their effects through several major mechanisms, including cell membrane disruption, protein and enzyme inhibition, interference with microbial DNA, oxidative stress induction, and anti-inflammatory effects that support wound healing. These mechanisms are described in detail below.

5.1. Disruption of Microbial Cell Membrane Integrity

Many plant extracts and essential oils are rich in lipophilic compounds such as terpenoids, saponins, and phenolic oils. These molecules interact with the lipid bilayers of bacterial, fungal, and viral membranes.

5.1.1. Lipid Solubilization

Lipophilic components insert themselves into microbial membranes, causing:

Increased membrane fluidity

Structural disorganization

Leakage of intracellular fluids

Tea tree oil, lemongrass oil, and neem oil are particularly effective in disrupting membrane integrity.

5.1.2. Permeability Changes

Alteration of membrane permeability leads to:

Ion imbalance

Loss of essential metabolites

Collapse of membrane potential

5.2. Denaturation of Proteins and Enzymatic Inhibition

Many phytochemicals bind to microbial proteins or enzymes, altering their structure and impairing biological processes.

5.2.1. Enzyme Inactivation

Compounds such as flavonoids, tannins, and alkaloids inhibit crucial microbial enzymes involved in:

Cell wall synthesis, Antiseptic gel, Topical antiseptic formulation, Herbal antiseptic gel, Hand sanitizer gels, Synthetic antiseptic gel, Antimicrobial gel formulations, Topical antimicrobial agents, Energy metabolism, Replication and transcription

For example:

Tannins precipitate microbial proteins.

Curcumin from turmeric inhibits bacterial division proteins.

5.2.2. Protein Denaturation

Polyphenols form complexes with microbial proteins, altering their shape and function, which leads to irreversible damage.

5.3. Interference with Microbial DNA and RNA

Certain herbal compounds can disrupt nucleic acids or interfere with their synthesis.

5.3.1. DNA Binding and Damage

Flavonoids, alkaloids, and quinones can:

Bind to microbial DNA
Cause strand breakage
Inhibit nucleic acid synthesis

5.3.2. Inhibition of Replication

Compounds like allicin (from garlic) and curcumin block microbial replication pathways, preventing cell division and colony formation.

5.4. Induction of Oxidative Stress in Microorganisms

Many herbal extracts act as natural oxidants, generating reactive oxygen species (ROS) that damage microbial structures.

5.4.1. Production of Reactive Oxygen Species

Polyphenols and terpenoids may induce oxidative stress, leading to:

Lipid peroxidation, Protein oxidation, DNA damage

5.4.2. Antioxidant–Prooxidant Dual Action

Some plant extracts exhibit dual behavior:

They protect human skin cells via antioxidant activity
They exert antimicrobial effects by producing oxidative stress in microbial cells

Examples include green tea extract and neem extract.

5.5. Anti-Inflammatory and Wound-Healing Support

Unlike chemical antiseptics, many herbal antiseptic gels provide therapeutic benefits to the skin in addition to antimicrobial action.

5.5.1. Reduction of Inflammation

Herbal extracts such as aloe vera, chamomile, and turmeric reduce:

Redness, Swelling, Pain associated with minor skin abrasions
urns, and skin irritation.

VI. APPLICATION OF HERBAL ANTISEPTIC GELS

Herbal antiseptic gels are widely applied in personal hygiene, healthcare, and cosmetic practices due to their broad-spectrum antimicrobial activity and superior skin compatibility. Their formulation, rich in plant-derived bioactive compounds, offers therapeutic benefits that extend beyond basic microbial inhibition. As a result, herbal antiseptic gels are increasingly used as natural and gentle alternatives to conventional synthetic antiseptics. This section reviews the major applications of herbal antiseptic gels as reported in contemporary scientific literature.

6.1. Application in Routine Hand Hygiene

One of the most common uses of herbal antiseptic gels is daily hand sanitization. These gels are applied to the hands to reduce microbial contamination acquired from:

Public surfaces
Food handling
Interpersonal contact
Environmental exposure

6.2. Application in Minor Wound Care

Herbal antiseptic gels are frequently used in the management of minor cuts, abrasions, burns, and insect bites. Their application helps to:

Inhibit wound pathogens such as *Staphylococcus aureus* and *Pseudomonas aeruginosa*
Reduce inflammation around wounded areas
Promote faster wound healing
Prevent secondary infections
Healing-promoting herbs like aloe vera, turmeric, and calendula accelerate tissue repair by stimulating collagen synthesis and epithelial regeneration.

6.3. Application in the Management of Skin Infections

Certain herbal antiseptic gels are formulated to target superficial skin infections and conditions associated with microbial overgrowth. Examples include:

6.3.1. Fungal Skin Infections

Herbal gels with antifungal properties—such as those containing turmeric, lemongrass, garlic, or clove oil—are used for:

Athlete's foot, Ringworm, Candidiasis

6.3.2. Scalp and Follicular Infections

Herbal formulations may also apply to itchy scalp, folliculitis, and dandruff due to their antibacterial and anti-inflammatory actions

6.4. Application in Personal and Cosmetic Care

Herbal antiseptic gels are increasingly incorporated into cosmetic and skin-care routines. They serve multiple functions:

Facial cleansers or spot-treatment gels
Post-shaving or post-waxing cooling gels
Natural deodorant alternatives
Gel-based moisturizers with antimicrobial properties
Aloe vera, cucumber, green tea, and chamomile extracts are commonly used for their soothing and hydrating effects.

6.5. Application in Healthcare and Community Settings

Herbal antiseptic gels function as natural antiseptics in various settings:

6.5.1. Hospitals and Clinics

Useful in cases where:
Frequent sanitization is required
Patients have sensitive skin
Alcohol-based sanitizers cause dermatitis
Though herbal gels may not replace standard hospital sanitizers, they serve as supportive alternatives for non-critical hygiene

VII. PREPARATION METHOD OF HERBAL ANTISEPTIC GELS

7.1. Selection of Active Herbal Ingredients

The first step in preparing herbal antiseptic gels is the selection of suitable plant materials, based on:

Antimicrobial potency: Selection of plants with proven antibacterial, antifungal, or antiviral activity (e.g., neem, turmeric, tea tree, aloe vera, lemongrass).
Skin compatibility: Preference for extracts that are non-irritating and moisturizing.
Availability and sustainability: Readily available plants that can be sustainably sourced.

The selected plant parts (leaves, roots, stems, flowers, seeds) are then washed, dried, and powdered or processed for extraction.

7.2. Extraction of Herbal Bioactive Compounds

The next step involves obtaining the active phytochemicals through appropriate extraction methods:

7.2.1. Aqueous Extraction

Plant material is boiled or soaked in water to obtain water-soluble compounds such as tannins, flavonoids, and polysaccharides.

Advantage: Safe, non-toxic, and suitable for hydrophilic bioactives.

7.2.2. Ethanolic or Hydro-Alcoholic Extraction

Ethanol or hydro-alcoholic solutions are used to extract both polar and non-polar compounds.

Advantage: Higher extraction efficiency for alkaloids, terpenoids, and essential oils.

7.2.3. Essential Oil Distillation

Steam distillation or hydrodistillation is used to obtain essential oils from aromatic plants (e.g., tea tree, lemongrass, eucalyptus)

7.3. Selection of Gelling Agents

Gelling agents are crucial to achieve the desired viscosity, spreadability, and stability. Commonly used agents include:

Natural polymers: Aloe vera gel, xanthan gum, guar gum, pectin, carrageenan.

Synthetic polymers: Carbopol, hydroxypropyl methylcellulose (HPMC), polyvinyl alcohol (PVA).

The choice depends on the intended texture, stability, and shelf life of the final product.

7.4. Formulation Process

A typical preparation process for herbal antiseptic gels includes the following steps:

7.4.1. Preparation of Gel Base

1. The gelling agent is dispersed in water or aqueous solvent.
2. The dispersion is allowed to swell completely, often with continuous stirring to prevent lumps.
3. Adjust pH using neutralizers (e.g., triethanolamine for Carbopol-based gels).

7.4.2. Incorporation of Active Herbal Extracts

The plant extract or essential oil is added to the gel base gradually with constant stirring to ensure uniform distribution.

For essential oils, solubilizers like tween 80 may be used to improve dispersion.

7.4.3. Addition of Other Excipients

Optional ingredients may include:

Humectants: Glycerin, propylene glycol (to maintain skin hydration)

Preservatives: Natural preservatives such as neem extract or mild synthetic preservatives to enhance shelf life

Fragrances: Mild natural aromas to improve acceptability.

VIII. CHALLENGES AND CONSIDERATIONS IN PREPARATION

From the literature, some challenges in preparing herbal antiseptic gels include:

1. Solubility of phytochemicals: Many active herbal compounds are poorly water-soluble, so appropriate solvents/co-solvents (e.g., PEG, propylene glycol) are needed.
2. Polymer-extract compatibility: Extracts may interact with gelling agents; e.g., pH changes, precipitation, or gel weakening.
3. Preservation: Herbal gels often need preservatives (parabens, etc.) to prevent microbial contamination, but concentration must be balanced to avoid skin irritation.
4. pH stability: The ionization state of polymers like Carbopol depends strongly on pH; small deviations may affect gel properties.
5. Batch reproducibility: Variability in plant extracts (due to plant source, extraction method) can lead to inconsistencies in gel performances
6. Scaling up: Methods that work at lab scale may present difficulties in larger batch manufacturing (mixing, uniformity, sterilization).

IX. CONCLUSION

In conclusion, the literature on herbal antiseptic gels presents a strongly favorable picture of their potential and versatility. Across numerous studies, formulations using plant-derived extracts demonstrate significant antimicrobial activity, often comparable to conventional antiseptic agents, while

offering added benefits in terms of safety, biocompatibility, and patient acceptability.

1. Efficacy and Safety

Many herbal gels formulated with extracts such as *Azadirachta indica*, *Curcuma longa*, *Ocimum* species, and essential oils have shown promising antimicrobial effects against common skin and oral pathogens. For example, polyherbal gels with neem, clove, and honey showed good antimicrobial activity without compromising physicochemical properties.

In the context of oral health, herbal dental gels containing *Zingiber officinale*, *Salvadora persica*, and *Cinnamomum zeylanicum* exhibited stronger antibacterial activity and remineralization potential than conventional fluoride gels, while remaining non-toxic to host cells.

These results reinforce that herbal antiseptic gels can serve as effective and safer alternatives to synthetic antiseptics, especially for topical applications.

2. Formulation Feasibility

The studies reviewed consistently employ well-established gelling agents, such as Carbopol-940, to produce stable, homogenous gels. The use of co-solvents, such as propylene glycol, helps in solubilizing active phytochemicals and ensuring uniform dispersion. Physicochemical parameters — pH, viscosity, spreadability — are routinely optimized and validated. Further, in vitro and in vivo evaluations affirm that these formulations are both stable and functionally effective.

3. Broad Therapeutic Applications

The utility of herbal antiseptic gels spans multiple therapeutic domains — from skin infection management and wound healing to oral health conditions like periodontitis and mouth ulcers. Their dual functionality (antimicrobial + anti-inflammatory) is especially valuable, as many plant extracts used in gels modulate inflammatory mediators.

4. Challenges and Future Directions

Despite the compelling advantages, several challenges remain: standardization of herbal extracts (to ensure consistent potency), long-term stability under different storage conditions, and regulatory hurdles for herbal products. Also, many current studies are limited to in vitro or small-scale in vivo assessments; more extensive clinical trials are needed

to confirm efficacy, safety, and patient acceptability in real-world settings.

REFERENCES

- [1] Munir, M., Shah, S. N. H., Almas, U., Khan, F. A., Zaidi, A., Bukhari, S. M., & Murtaza, G. (2021). An assessment of the wound healing potential of a herbal gel containing an *Azadirachta indica* leaf extract. *Veterinárni medicína*, 66(3), 99–109.
- [2] Sindhusha, S., et al. (2024). Formulation of Neem and Echinacea Gel for Oral Health Along With the Evaluation of Antimicrobial, Cytotoxic, Anti-inflammatory, and Free Radical Scavenging Activity: An In Vitro Study. PubMed.
- [3] Sushmitha, K. R., Koppam, M., & Kulkarni, S. V. (2019). Formulation and evaluation of topical herbal gel for treatment of acne using *Withania somnifera*. *Journal of Biomedical and Pharmaceutical Research*, 8(3), 161–168.
- [4] Study on essential-oil-based herbal gel: Formulation and Comparison of Herbal Gels Containing Essential Oils and their Antimicrobial Evaluation. PubMed.
- [5] Pharmacognosy study: Herbal gel prepared from *Azadirachta indica*, *Curcuma longa*, *Berberis aristata* & *Rubia cordifolia*: Antimicrobial Activity. *International Journal of Pharmacognosy and Pharmaceutical Sciences*.
- [6] Formulation of a poly-herbal gel: Formulation and characterization of a poly herbal gel (*Aloe vera*, *Azadirachta indica*, *Lycopersicon esculentum*). *World Journal of Pharmaceutical Research*.
- [7] Trio herbal gel study: Formulation and evaluation of novel herbal trio gel containing brown flax seed extract, Carbopol, and carboxymethyl cellulose. PubMed.
- [8] Purkar, P. Y., Ingale, P., Batwal, K., Rathod, S., & Gaikwad, Y. (2025). Formulation and evaluation of antimicrobial herbal gel (betel leaves & giloy). *World Journal of Biology Pharmacy and Health Sciences*, 21(2), 288–294.
- [9] Anti-acne multi-plant gel: Preparation and evaluation of herbal gel containing multiple plant extracts (*Azadirachta indica*, *Curcuma longa*, *Aloe vera*) for acne treatment. *STMJ Journals*.
- [10] Gulkari, V., et al. (2020). Formulation of herbal gel from *Murraya koenigii* and *Azadirachta*

indica leaves extract and its antifungal activity.
World Journal of Pharmaceutical Research.

- [11] Emulgel research: Herbal emulgel containing Azadirachta indica and other natural oils (BCO, NO) based on Carbopol-934 for wound healing applications. Ancient Science of Life.
- [12] Kawee-ai, A., Kapusta, I., Pawłowska, A., Adamczyk, G., & Żurek, N. (2025). Advancing gel systems with natural extracts: Antioxidant, antimicrobial applications, and sustainable innovations. Gels, 11, 125. (Repeated because it's a key review; use once)