A Review on Herbal Hand Sanitizer Prepared from Neem and Tulsi for Antimicrobial Protection

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Abstract*—Hand hygiene plays a crucial role in preventing the transmission of infectious microorganisms and maintaining public health. The increasing prevalence of infectious diseases and the growing awareness regarding personal hygiene have significantly increased the use of hand sanitizers worldwide. Conventional alcohol-based sanitizers are effective against pathogens; however, their frequent use may cause skin irritation, dryness, and allergic reactions. As a result, herbal hand sanitizers have emerged as safer and eco-friendly alternatives due to their natural composition and reduced side effects. Neem (Azadirachta indica) and Tulsi (Ocimum sanctum) are well-known medicinal plants possessing significant antimicrobial, antioxidant, anti-inflammatory, and therapeutic properties. These plants contain important phytoconstituents such as nimbin, azadirachtin, eugenol, flavonoids, tannins, ursolic acid, and essential oils, which contribute to their antimicrobial effectiveness against various bacteria, fungi, and viruses. This review highlights the importance of herbal hand sanitizers prepared from Neem and Tulsi for antimicrobial protection. The paper discusses their phytochemical constituents, antimicrobial mechanisms, advantages over alcohol-based sanitizers, applications, benefits, limitations, and future prospects. Herbal sanitizers provide effective microbial protection while maintaining skin moisture and minimizing harmful effects associated with synthetic sanitizers. In addition, they are biodegradable, economical, and environmentally friendly. The growing demand for natural healthcare products and increased post-COVID awareness regarding hand hygiene have further promoted the development of herbal sanitizing formulations. Overall, Neem and Tulsi-based herbal hand sanitizers represent promising alternatives for safe, effective, and sustainable infection control and personal hygiene maintenance.

***Index Terms*—Herbal Hand Sanitizer, Neem, Tulsi, Antimicrobial Activity, Azadirachta indica, Ocimum sanctum, Hand Hygiene, Herbal Formulation, Natural Disinfectants, Phytochemicals, Antibacterial Activity, Herbal Healthcare Products**

I. INTRODUCTION

1.1 Hand Hygiene and Microbial Protection

Hand hygiene is one of the most important methods for preventing the spread of infectious microorganisms. Human hands frequently come into contact with contaminated surfaces, leading to the transmission of bacteria, viruses, and fungi. Proper hand sanitation helps reduce healthcare-associated and community infections [1].

1.2 Importance of Hand Sanitizers

Hand sanitizers are widely used for maintaining personal hygiene when soap and water are not available. During the COVID-19 pandemic, the demand for sanitizers increased significantly due to increased awareness regarding infection control and disease prevention [2].

1.3 Need for Herbal Hand Sanitizers

Continuous use of alcohol-based sanitizers may cause skin irritation, dryness, and allergic reactions. Herbal hand sanitizers are considered safer alternatives because they contain natural ingredients with antimicrobial properties and fewer side effects [3].

1.4 Role of Neem and Tulsi

Neem (Azadirachta indica) and Tulsi (Ocimum sanctum) are well-known medicinal plants used in traditional medicine. Neem contains active

compounds such as nimbin and azadirachtin, while Tulsi contains eugenol and ursolic acid, which possess strong antimicrobial and antioxidant activities [4].

1.5 Aim of the Review

This review focuses on the antimicrobial importance of Neem and Tulsi in herbal hand sanitizers and highlights their phytochemical constituents, mechanism of action, advantages, and applications in modern hand hygiene practices.

Fig No:1 Neem and Tulsi Plant

II. LITERATURE REVIEW

Several studies have reported the effectiveness of herbal hand sanitizers prepared from medicinal plants for antimicrobial protection. Herbal formulations containing Neem and Tulsi have gained considerable attention due to their broad-spectrum antimicrobial activity and reduced side effects compared to synthetic sanitizers.

Neem (Azadirachta indica) has been extensively studied for its antibacterial, antifungal, antiviral, and anti-inflammatory properties. The presence of phytochemicals such as nimbin, azadirachtin, flavonoids, tannins, and essential oils contribute to its strong antimicrobial action against various pathogenic microorganisms. Neem extracts are effective against both Gram-positive and Gram-negative bacteria and are widely used in herbal healthcare preparations.

Tulsi (Ocimum sanctum) is another important medicinal herb traditionally used in Ayurveda for treating various infections and respiratory disorders. Tulsi contains bioactive compounds including eugenol, ursolic acid, and essential oils that exhibit antimicrobial, antioxidant, and immunomodulatory activities. Studies have shown that Tulsi extracts inhibit the growth of several harmful microorganisms and improve hygienic protection.

Many researchers have suggested that combining Neem and Tulsi in herbal sanitizer formulations enhances antimicrobial effectiveness due to synergistic action between their phytochemical constituents. Herbal hand sanitizers formulated with these plant extracts provide efficient microbial protection while maintaining skin moisture and minimizing irritation.

Recent studies also indicate that herbal sanitizers are becoming increasingly popular after the COVID-19 pandemic because of growing consumer preference toward natural and eco-friendly healthcare products. These formulations are considered economical, biodegradable, and safer for long-term use.

Overall, literature findings support the potential use of Neem and Tulsi as effective herbal ingredients for developing antimicrobial hand sanitizers suitable for routine hygiene applications.

III. CONCEPT OF HAND HYGIENE

Hand hygiene refers to the practice of cleaning hands to remove dirt, microorganisms, and harmful pathogens in order to prevent the spread of infectious diseases [5]. It is considered one of the simplest and most effective methods for controlling microbial transmission in healthcare settings as well as in daily life. Human hands are continuously exposed to contaminated surfaces, respiratory droplets, and infected materials. Pathogenic microorganisms such as bacteria, viruses, and fungi can survive on the skin surface and spread easily through direct or indirect contact [6]. Proper hand hygiene helps in reducing microbial load and minimizing the risk of infection.

Hand hygiene can be performed by different methods including:

- Hand washing with soap and water
- Use of alcohol-based hand sanitizers
- Use of herbal or natural hand sanitizers

Soap and water are generally recommended when hands are visibly dirty, whereas hand sanitizers are preferred when immediate cleansing is required or water is unavailable [7]. Herbal hand sanitizers have gained popularity because they provide antimicrobial protection with reduced skin irritation and fewer chemical side effects.

The importance of hand hygiene became more significant during the COVID-19 pandemic, where

regular hand sanitization was strongly recommended to reduce viral transmission and improve public health awareness [8]. Proper hand hygiene practices are therefore essential for maintaining personal hygiene and preventing communicable diseases.

IV. IMPORTANCE OF HERBAL HAND SANITIZERS

Herbal hand sanitizers are gaining increasing importance due to their natural composition, antimicrobial effectiveness, and skin-friendly properties [9]. These sanitizers are prepared using medicinal plant extracts that possess antibacterial, antifungal, antiviral, and antioxidant activities.

Conventional alcohol-based sanitizers are effective against microorganisms; however, frequent use may cause dryness, irritation, itching, and damage to the skin barrier [10]. In contrast, herbal hand sanitizers contain natural phytoconstituents that provide antimicrobial protection while maintaining skin moisture and softness. Medicinal plants such as Neem (Azadirachta indica) and Tulsi (Ocimum sanctum) are widely used in herbal sanitizer formulations because of their strong antimicrobial potential. Active constituents including nimbin, azadirachtin, eugenol, flavonoids, tannins, and essential oils help inhibit the growth of harmful microorganisms [11].

Herbal sanitizers are also considered environmentally friendly and biodegradable because they contain fewer synthetic chemicals. These products are generally safer for long-term and repeated use, especially for individuals with sensitive skin or allergic reactions to alcohol-based formulations [12]. The COVID-19 pandemic significantly increased public awareness regarding personal hygiene and infection prevention. As a result, the demand for herbal healthcare products and natural sanitizing agents has increased worldwide [13]. Herbal hand sanitizers are therefore emerging as promising alternatives for effective and safe antimicrobial protection.

V. OVERVIEW OF NEEM (AZADIRACHTA INDICA)

Neem (Azadirachta indica) is a well-known medicinal plant belonging to the family Meliaceae. It is commonly referred to as the “Village Pharmacy” due to its wide range of therapeutic applications in traditional medicine systems such as Ayurveda and Siddha [14]. Different parts of the Neem plant including leaves, bark, seeds, and oil are used for medicinal purposes.

Fig No:2 Plant of Azadirachta indica

5.1 Biological Source

Neem consists of the fresh or dried leaves and seeds of Azadirachta indica, a tropical evergreen tree mainly found in India and other Asian countries [15].

5.2 Phytochemical Constituents

Neem contains several biologically active phytochemicals responsible for its medicinal properties. Major constituents include:

- Nimbin
- Azadirachtin
- Nimbolide
- Flavonoids
- Tannins
- Glycosides
- Essential oils

These compounds contribute to the antimicrobial, antioxidant, anti-inflammatory, and antifungal activities of Neem [16].

5.3 Antimicrobial Activity

Neem exhibits strong antimicrobial activity against various Gram-positive and Gram-negative bacteria, fungi, and viruses. Neem extracts interfere with microbial growth by damaging the cell membrane and inhibiting essential metabolic activities of microorganisms [17].

Studies have shown that Neem is effective against common pathogens such as:

- Staphylococcus aureus
- Escherichia coli
- Candida albicans
- Salmonella species

Due to these properties, Neem is widely used in herbal healthcare and hygiene products [18].

5.4 Medicinal Uses

Neem possesses multiple medicinal applications including:

- Antibacterial activity
- Antifungal activity
- Anti-inflammatory action
- Antioxidant property
- Wound healing activity
- Skin protection

Neem extracts are commonly incorporated into herbal soaps, creams, toothpaste, shampoos, and hand sanitizers for improving hygienic protection and skin health [19].

VI. OVERVIEW OF TULSI (OCIMUM SANCTUM)

Tulsi (Ocimum sanctum), commonly known as Holy Basil, is an important medicinal herb belonging to the family Lamiaceae. It is widely used in Ayurveda due to its therapeutic, antimicrobial, antioxidant, and immunomodulatory properties [20]. Tulsi is regarded as a sacred plant in India and has been traditionally used for the treatment of various infectious and respiratory disorders.

6.1 Biological Source

Tulsi consists of the dried leaves and flowering tops of Ocimum sanctum, an aromatic medicinal plant cultivated mainly in India and tropical regions [21].

Fig No: 3 Ocimum sanctum

6.2 Phytochemical Constituents

Tulsi contains several bioactive compounds responsible for its medicinal and antimicrobial activities. Major phytochemicals include:

- Eugenol
- Ursolic acid
- Rosmarinic acid
- Flavonoids
- Tannins
- Saponins
- Essential oils

These constituents contribute to the antioxidant, antibacterial, antiviral, and anti-inflammatory properties of Tulsi [22].

6.3 Antimicrobial Activity

Tulsi possesses strong antimicrobial activity against various pathogenic microorganisms. The essential oils and phenolic compounds present in Tulsi help inhibit microbial growth by damaging microbial cell membranes and interfering with metabolic functions [23].

Tulsi extracts are effective against:

- Staphylococcus aureus
- Escherichia coli
- Pseudomonas aeruginosa
- Candida albicans

Because of these antimicrobial properties, Tulsi is commonly used in herbal formulations and hygienic products [24].

6.4 Medicinal Uses

Tulsi has numerous medicinal applications including:

- Antibacterial activity

- Antiviral activity
- Antifungal activity
- Antioxidant effect
- Anti-inflammatory action
- Immune-boosting property

Tulsi is widely incorporated into herbal medicines, herbal teas, cough syrups, skincare products, and herbal hand sanitizers for improving health and hygienic protection [25].

VII. MECHANISM OF ANTIMICROBIAL ACTION OF NEEM AND TULSI

Neem and Tulsi exhibit antimicrobial activity through the presence of various bioactive phytochemicals that act against bacteria, fungi, and viruses [26]. These medicinal plants contain compounds capable of inhibiting microbial growth and reducing the spread of infectious microorganisms.

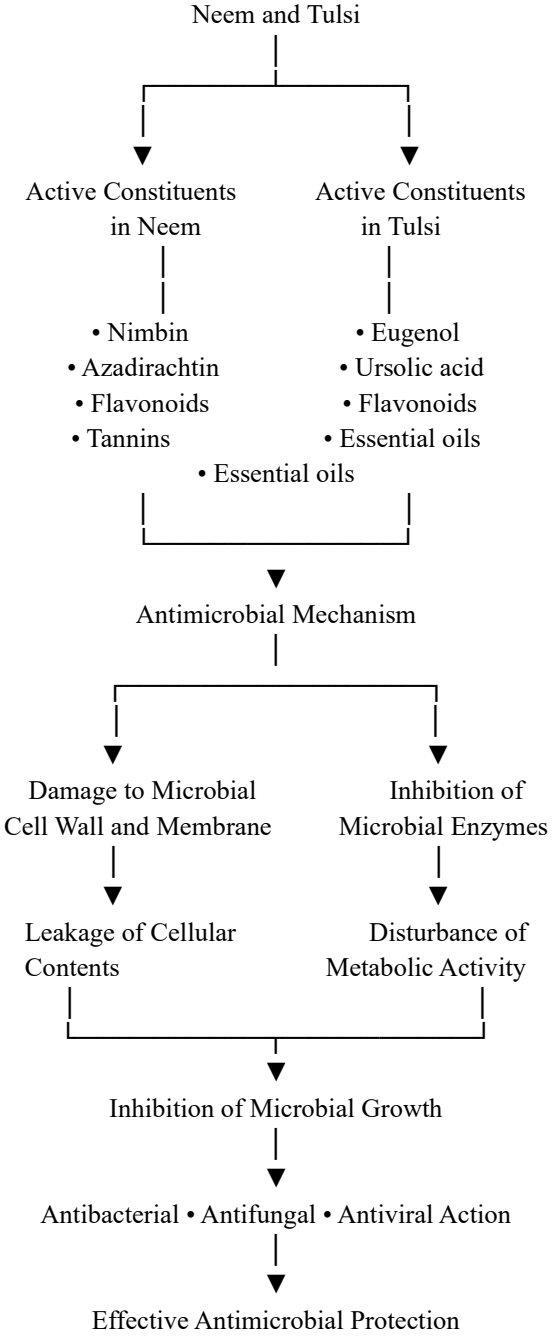
Neem contains active constituents such as nimbin, azadirachtin, flavonoids, tannins, and essential oils. These compounds damage the microbial cell wall and cell membrane, leading to leakage of cellular contents and eventual death of microorganisms [27]. Neem phytochemicals also interfere with microbial enzyme activity and inhibit protein synthesis required for microbial survival.

Tulsi contains eugenol, ursolic acid, flavonoids, and aromatic essential oils that contribute to its antimicrobial action. Eugenol is particularly known for disrupting the structural integrity of microbial cell membranes and inhibiting metabolic processes [28]. Tulsi extracts also possess antioxidant properties that help protect tissues against oxidative stress caused by infections.

The combined use of Neem and Tulsi in herbal hand sanitizers may produce synergistic antimicrobial effects. Their phytochemical constituents work together to inhibit the growth of various pathogenic bacteria and fungi while providing safer and skin-friendly antimicrobial protection [29].

In addition to antibacterial activity, Neem and Tulsi also exhibit antiviral and antifungal properties, making them useful ingredients in natural sanitizing and healthcare formulations [30].

Flow Chart: Mechanism of Antimicrobial Action of Neem and Tulsi



VIII. PHYTOCHEMICAL CONSTITUENTS RESPONSIBLE FOR ANTIMICROBIAL ACTIVITY

Medicinal plants contain various phytochemicals that contribute to their antimicrobial and therapeutic properties. Neem and Tulsi are rich sources of biologically active compounds responsible for

inhibiting the growth of microorganisms and providing protection against infections [31].

8.1 Nimbin

Nimbin is an important bioactive compound present in Neem. It possesses antibacterial, antifungal, anti-inflammatory, and antiviral activities. Nimbin helps inhibit microbial growth by interfering with cellular functions and damaging microbial membranes [32].

8.2 Azadirachtin

Azadirachtin is one of the major phytoconstituents of Neem known for its antimicrobial and insecticidal properties. It affects microbial metabolism and prevents the growth and survival of harmful microorganisms [33].

8.3 Eugenol

Eugenol is the principal active constituent present in Tulsi essential oil. It exhibits strong antibacterial, antifungal, antioxidant, and anti-inflammatory properties. Eugenol disrupts microbial cell membranes and inhibits enzymatic activity within microbial cells [34].

8.4 Ursolic Acid

Ursolic acid is a pentacyclic triterpenoid found in Tulsi with significant antimicrobial and antioxidant properties. It helps reduce microbial proliferation and supports tissue protection against oxidative damage [35].

8.5 Flavonoids

Flavonoids are naturally occurring polyphenolic compounds present in both Neem and Tulsi. These compounds possess antioxidant and antimicrobial activities by inhibiting microbial enzymes and neutralizing free radicals [36].

8.6 Tannins

Tannins exhibit antimicrobial effects by precipitating microbial proteins and disrupting cell membrane integrity. They also contribute to wound healing and protective actions against infections [37].

8.7 Essential Oils

Essential oils present in Neem and Tulsi contain aromatic compounds with broad-spectrum antimicrobial activity. These oils penetrate microbial cell membranes, leading to cell damage and inhibition of microbial growth [38].

IX. ADVANTAGES OF HERBAL SANITIZERS OVER ALCOHOL-BASED SANITIZERS

Herbal hand sanitizers offer several advantages compared to conventional alcohol-based sanitizers due to their natural composition and skin-friendly properties [39]. These formulations are increasingly preferred because they provide antimicrobial protection with reduced adverse effects.

One of the major advantages of herbal sanitizers is reduced skin irritation. Frequent use of alcohol-based sanitizers may cause dryness, itching, redness, and dermatitis due to excessive removal of skin moisture [40]. Herbal sanitizers prepared from Neem and Tulsi help maintain skin hydration and softness because of the presence of natural phytoconstituents.

Herbal sanitizers also possess broad-spectrum antimicrobial activity. Bioactive compounds such as nimbin, azadirachtin, eugenol, flavonoids, tannins, and essential oils exhibit antibacterial, antifungal, antiviral, and antioxidant properties [41]. These compounds effectively inhibit the growth of harmful microorganisms.

Another important advantage is their safety during long-term use. Herbal formulations generally contain fewer synthetic chemicals and are considered less toxic and more biocompatible than chemical sanitizers [42]. They are therefore suitable for individuals with sensitive skin or allergic reactions to alcohol-based products.

Herbal hand sanitizers are also biodegradable and environmentally friendly. Unlike synthetic sanitizers, they produce less chemical pollution and are prepared from renewable natural resources [43]. Additionally, herbal products are often economical and easily prepared using locally available medicinal plants.

The pleasant aroma and therapeutic properties of herbal ingredients further increase consumer acceptance of herbal sanitizers [44]. Due to these benefits, herbal hand sanitizers are emerging as promising alternatives for effective antimicrobial protection and routine hygiene maintenance.

X. TYPES OF HERBAL HAND SANITIZERS

Herbal hand sanitizers are available in different formulations depending on their composition, method of application, and consistency. These formulations are prepared using medicinal plant extracts and natural antimicrobial agents to provide effective hygienic protection [45].

10.1 Herbal Gel Sanitizers

Herbal gel sanitizers are the most commonly used formulations due to their ease of application and good skin adherence. These sanitizers contain herbal extracts along with gelling agents such as carbopol or aloe vera gel. Neem and Tulsi extracts are frequently incorporated because of their antimicrobial properties [46].

10.2 Herbal Spray Sanitizers

Herbal spray sanitizers are liquid formulations applied directly onto the hands using spray pumps. They provide quick drying and convenient usage without leaving sticky residues. Essential oils and herbal extracts are commonly used in these formulations for antimicrobial protection [47].

10.3 Foam-based Herbal Sanitizers

Foam sanitizers produce a light foam during application and spread easily on the skin surface. These formulations are preferred because they require less quantity and provide uniform coverage on the hands [48].

10.4 Alcohol-free Herbal Sanitizers

Alcohol-free herbal sanitizers are prepared using plant extracts and natural antimicrobial agents without ethanol or isopropyl alcohol. These formulations are suitable for individuals with sensitive skin and reduce the risk of skin dryness and irritation [49].

10.5 Herbal Sanitizer Wipes

Herbal sanitizer wipes are disposable tissues impregnated with herbal antimicrobial solutions. They are useful for travel and quick hand cleaning purposes when water is unavailable [50].

Different types of herbal hand sanitizers are developed to improve user convenience, safety, and antimicrobial

effectiveness while maintaining skin health and hygiene.

XI. APPLICATIONS AND BENEFITS OF HERBAL HAND SANITIZERS

11.1 Applications of Herbal Hand Sanitizers

- Used in hospitals and healthcare centers for infection control [51].
- Applied in schools, colleges, offices, and public places for routine hand hygiene [52].
- Helpful in reducing the transmission of bacteria, fungi, and viruses [53].
- Used during travel and outdoor activities when soap and water are unavailable [54].
- Incorporated in personal healthcare and hygiene products [55].
- Useful during pandemic situations such as COVID-19 for maintaining hand sanitation [56].

11.2 Benefits of Herbal Hand Sanitizers

- Provide effective antimicrobial protection against harmful microorganisms [57].
- Contain natural ingredients with antibacterial and antifungal properties [58].
- Reduce skin dryness and irritation caused by alcohol-based sanitizers [59].
- Help maintain skin moisture and softness [60].
- Possess antioxidant and anti-inflammatory activities [61].
- Biodegradable and environmentally friendly in nature [62].
- Safer for long-term and repeated use [63].
- Suitable for individuals with sensitive skin [64].
- Prepared from economical and easily available medicinal plants [65].
- Possess pleasant aroma due to essential oils and herbal extracts [66].

XII. LIMITATIONS AND CHALLENGES OF HERBAL HAND SANITIZERS

Although herbal hand sanitizers provide several advantages, they also possess certain limitations and challenges related to formulation, stability, effectiveness, and commercialization [67].

12.1 Variation in Herbal Composition

The concentration of phytochemicals in medicinal plants may vary depending on climate, soil conditions, harvesting methods, and storage conditions [68]. This variation may affect the antimicrobial effectiveness of herbal sanitizers.

12.2 Stability Problems

Herbal formulations may show instability during storage due to degradation of natural constituents [69]. Changes in color, odor, viscosity, and antimicrobial activity may occur over time.

12.3 Short Shelf Life

Herbal sanitizers generally possess shorter shelf life compared to synthetic formulations because natural ingredients are more susceptible to microbial contamination and oxidation [70].

12.4 Limited Standardization

Standardization of herbal formulations is difficult because plant extracts contain multiple phytochemicals in varying concentrations [71].
Lack of uniform quality control may affect product consistency.

12.5 Reduced Immediate Action

Some herbal sanitizers may exhibit slower antimicrobial action compared to alcohol-based sanitizers [72]. Their effectiveness may depend on concentration and contact time.

12.6 Risk of Allergic Reactions

Certain individuals may develop hypersensitivity or allergic reactions to specific herbal extracts or essential oils [73].

12.7 Commercial and Regulatory Challenges

Herbal products require proper safety evaluation and regulatory approval before commercialization [74].
Limited scientific data and clinical studies may restrict wider acceptance of herbal sanitizers.

12.8 Preservation Issues

Natural formulations may require suitable preservatives to prevent microbial growth during storage [75]. Improper preservation can reduce product safety and effectiveness.

XIII. FUTURE PROSPECTS

Herbal hand sanitizers have gained significant attention in recent years due to increasing awareness regarding natural healthcare products and personal hygiene maintenance [76]. The growing preference for plant-based formulations is expected to increase the demand for herbal sanitizers in the future.

Medicinal plants such as Neem and Tulsi possess strong antimicrobial, antioxidant, and anti-inflammatory properties, making them promising ingredients for the development of safer and more effective hand hygiene products [77]. Further research on phytochemical constituents and their mechanisms of action may help improve the antimicrobial efficiency of herbal formulations.

Advancements in herbal formulation technology may lead to the development of more stable, fast-acting, and long-lasting herbal sanitizers [78]. The incorporation of natural preservatives, essential oils, and novel delivery systems can improve product stability and shelf life.

Increasing public awareness regarding the harmful effects of excessive synthetic chemical use has encouraged consumers to adopt eco-friendly and biodegradable products [79]. Herbal sanitizers prepared from renewable natural resources may therefore become important alternatives to conventional alcohol-based sanitizers.

Future studies focusing on clinical evaluation, quality control, standardization, and large-scale production may enhance the commercial acceptance of herbal sanitizers [80]. The integration of traditional herbal knowledge with modern pharmaceutical technology can further contribute to the development of effective antimicrobial products for healthcare and community use. Overall, herbal hand sanitizers prepared from Neem and Tulsi possess strong potential for future applications in infection control, personal hygiene, and natural healthcare systems.

XIV. CONCLUSION

Herbal hand sanitizers prepared from Neem (Azadirachta indica) and Tulsi (Ocimum sanctum) have gained considerable importance as natural alternatives to synthetic and alcohol-based sanitizers. The increasing prevalence of infectious diseases and growing awareness regarding personal hygiene have significantly increased the demand for effective hand sanitizing agents. Herbal formulations are widely preferred because they provide antimicrobial protection with fewer side effects and improved skin compatibility.

Neem and Tulsi are well-known medicinal plants extensively used in traditional systems of medicine due to their broad therapeutic potential. These plants contain various phytochemical constituents such as nimbin, azadirachtin, eugenol, ursolic acid, flavonoids, tannins, and essential oils that possess antibacterial, antifungal, antiviral, antioxidant, and anti-inflammatory activities. The presence of these bioactive compounds contributes to the strong antimicrobial action of herbal hand sanitizers against different pathogenic microorganisms.

Compared to conventional alcohol-based sanitizers, herbal sanitizers offer several advantages including reduced skin dryness, irritation, itching, and toxicity. Herbal formulations help maintain skin moisture and softness while providing effective microbial protection. In addition, they are biodegradable, environmentally friendly, economical, and safer for long-term and repeated use. These properties make herbal sanitizers suitable for routine hygiene practices in healthcare settings as well as daily life.

The COVID-19 pandemic further highlighted the importance of hand hygiene and infection prevention, resulting in increased utilization of hand sanitizers worldwide. This has also promoted the popularity of herbal healthcare products and natural disinfectants due to consumer preference toward safer and eco-friendly alternatives. Neem and Tulsi-based sanitizers therefore represent promising formulations for improving hygienic protection and reducing microbial transmission.

Although herbal hand sanitizers possess several benefits, certain limitations such as formulation instability, limited standardization, shorter shelf life, and variation in phytochemical composition still remain challenges for researchers and manufacturers. Further scientific studies and technological advancements are necessary to improve the stability, effectiveness, and commercial acceptability of herbal formulations.

Overall, herbal hand sanitizers prepared from Neem and Tulsi demonstrate significant potential as effective antimicrobial agents for maintaining personal hygiene and preventing infectious diseases. The integration of

traditional herbal knowledge with modern pharmaceutical approaches may further contribute to the development of safe, efficient, and sustainable herbal sanitizing products for future healthcare applications.

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