

Formulation & Evaluation of Hand Sanitizer Gel containing Infusion of Butterfly Pea Flower (*Clitoria Ternatea*) as Antibacterial Agent

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Abstract—The increasing awareness regarding hand hygiene and the growing demand for herbal-based personal care products have encouraged the development of natural and effective hand sanitizing formulations. The present research work focuses on the formulation and evaluation of a herbal hand sanitizer gel containing an infusion of Butterfly Pea Flower (*Clitoria ternatea*) as a natural antibacterial agent. Butterfly pea flower is well known for its rich phytochemical constituents such as flavonoids, anthocyanins, tannins, and phenolic compounds, which possess significant antimicrobial and antioxidant properties. The primary objective of this study was to formulate a stable, safe, and effective herbal hand sanitizer gel using the infusion of butterfly pea flower and to evaluate its physicochemical as well as antibacterial characteristics.

The hand sanitizer gel was prepared using suitable gelling agents, humectants, preservatives, and other excipients along with the herbal infusion. Antibacterial activity of the formulation was assessed against common pathogenic microorganisms using standard microbiological methods. The prepared formulation exhibited satisfactory physical properties with good consistency, smooth texture, acceptable pH, and enhanced spreadability. The antibacterial studies demonstrated effective inhibitory action against selected bacterial strains, indicating the potential of butterfly pea flower infusion as a natural antibacterial ingredient in hand sanitizer formulations. The study concludes that the formulated herbal hand sanitizer gel containing butterfly pea flower infusion can serve as a promising alternative to conventional chemical-based sanitizers due to its antibacterial efficacy, natural origin, skin-friendly nature, and aesthetic appeal. The developed formulation may contribute to the advancement of herbal healthcare products with improved consumer acceptance and reduced side effects.

Index Terms—Herbal hand sanitizer gel, *Clitoria ternatea*, Butterfly pea flower, Antibacterial activity, Herbal formulation, Infusion, Physicochemical evaluation, Natural sanitizer, Antimicrobial agent, Herbal cosmetics.

I. Introduction

Hand hygiene plays a crucial role in preventing the transmission of infectious diseases and maintaining public health. Human hands are continuously exposed to various **pathogenic microorganisms** through contact with contaminated surfaces, environmental pollutants, and infected individuals. These microorganisms can easily spread infections such as respiratory disorders, gastrointestinal diseases, skin infections, and viral illnesses. Therefore, maintaining proper hand cleanliness has become an essential preventive healthcare practice worldwide. Traditional handwashing with soap and water is considered effective; however, it may not always be convenient in situations where water is unavailable. This limitation has led to the widespread use of **hand sanitizers** as an alternative and portable hygiene solution.

Hand sanitizers are formulations designed to reduce or eliminate microbial contamination from the hands. They are generally available in the form of **gels, foams, sprays, and liquids**, with gel formulations being the most preferred due to their ease of application, non-sticky texture, and prolonged contact time with the skin. Most commercially available sanitizers contain high concentrations of **alcohol**, such as ethanol or isopropyl alcohol, which provide rapid antimicrobial activity. However, excessive use of alcohol-based sanitizers may lead to **skin dryness, irritation, allergic reactions, and damage to the natural skin barrier**. These disadvantages have encouraged researchers to explore safer and more skin-friendly alternatives derived from natural sources. In recent years, there has been increasing interest in the development of **herbal hand sanitizers** containing plant-based antibacterial agents. Herbal formulations are considered comparatively safer, biodegradable, eco-friendly, and less toxic. They also offer additional benefits such as antioxidant, moisturizing, and soothing effects on the skin. The growing demand for natural healthcare products has significantly promoted research into herbal sanitizing formulations with enhanced therapeutic potential.

Herbal Formulations and Their Importance in Modern Healthcare

The use of **medicinal plants** for the treatment and prevention of diseases has been practiced since ancient times in various traditional systems of medicine. Herbal formulations have gained significant popularity in recent years due to their natural origin, reduced side effects, cost-effectiveness, and therapeutic efficacy. Modern consumers increasingly prefer products containing **plant-derived bioactive compounds** because of concerns regarding the harmful effects associated with synthetic chemicals. As a result, the pharmaceutical and cosmetic industries are focusing extensively on the development of herbal-based healthcare and personal hygiene products. Herbal formulations contain a wide range of **phytoconstituents** such as alkaloids, flavonoids, tannins, glycosides, phenolic compounds, and essential oils. These compounds exhibit various biological activities including **antibacterial, antifungal, antiviral, anti-inflammatory, antioxidant, and wound-healing properties**. Due to these multifunctional properties, medicinal plants are considered promising alternatives for incorporation into hand sanitizing formulations. Herbal sanitizers not only provide antimicrobial protection but also help maintain skin hydration and reduce irritation commonly caused by alcohol-rich preparations. The increasing prevalence of microbial resistance against conventional antimicrobial agents has further highlighted the importance of herbal medicines. Plant-based antibacterial agents act through multiple mechanisms, thereby reducing the possibility of resistance development. In addition, herbal products are generally biodegradable and environmentally sustainable, making them more acceptable for long-term use. The incorporation of medicinal plant extracts or infusions into topical formulations can enhance product efficacy while improving consumer safety and satisfaction. Therefore, the development of herbal hand sanitizer gels represents an innovative approach in modern healthcare by combining the advantages of **natural antibacterial activity, skin compatibility, and eco-friendly formulation strategies**. Such formulations have the potential to serve as effective alternatives to synthetic sanitizing products.

Introduction to Butterfly Pea Flower (*Clitoria ternatea*)

Clitoria ternatea, commonly known as **Butterfly Pea Flower**, is a perennial herbaceous plant belonging to the family **Fabaceae**. The plant is widely distributed in tropical and subtropical regions and is traditionally used in Ayurvedic and herbal medicine for various therapeutic purposes. Butterfly pea flower is easily recognized by its vibrant blue-colored flowers, which are rich in naturally occurring pigments known as **anthocyanins**. Apart from its ornamental value, the plant possesses several medicinal and pharmacological properties that make it highly valuable in healthcare applications. The flowers of *Clitoria ternatea* contain numerous bioactive constituents including **flavonoids, phenolic acids, tannins, alkaloids, glycosides,**

anthocyanins, and saponins. These phytochemicals are responsible for its broad spectrum of biological activities such as antibacterial, antioxidant, anti-inflammatory, antidiabetic, neuroprotective, and antimicrobial effects. The antioxidant potential of butterfly pea flower helps protect cells against oxidative stress and free radical damage, while its antibacterial activity contributes to the inhibition of pathogenic microorganisms.

In recent years, butterfly pea flower has attracted considerable attention in the pharmaceutical, cosmetic, and food industries because of its natural colorant properties and therapeutic potential. The aqueous infusion of the flower is widely used in herbal beverages and skincare preparations due to its safety and bioactivity. Scientific studies have demonstrated that extracts of *Clitoria ternatea* exhibit effective antibacterial action against several gram-positive and gram-negative bacteria, indicating its suitability for use in topical antimicrobial formulations. Because of its **natural antibacterial properties, skin-friendly nature, antioxidant activity, and attractive appearance**, butterfly pea flower infusion has emerged as a promising ingredient for the formulation of herbal hand sanitizer gels aimed at improving hygiene and skin protection.

Rationale and Significance of the Present Study

The formulation of a herbal hand sanitizer gel using *Clitoria ternatea* infusion may provide several advantages including improved skin compatibility, reduced chemical toxicity, natural fragrance and color, antioxidant protection, and effective antimicrobial activity. In addition, herbal sanitizers may enhance user acceptance due to their eco-friendly and plant-based composition. The gel dosage form also offers benefits such as easy application, better spreadability, prolonged retention on the skin, and improved consumer convenience.

Hence, the present research aims to formulate and evaluate a herbal hand sanitizer gel containing butterfly pea flower infusion and to investigate its physicochemical characteristics and antibacterial effectiveness. The study may contribute to the development of innovative herbal healthcare products with improved safety, efficacy, and commercial potential.

II. OBJECTIVES

1. To formulate a **herbal hand sanitizer gel** containing an infusion of Butterfly Pea Flower (*Clitoria ternatea*) as a natural antibacterial agent.
2. To evaluate the **antibacterial activity** of butterfly pea flower infusion against selected pathogenic microorganisms.
3. To develop a hand sanitizer gel with desirable **physicochemical properties** such as suitable pH, viscosity, homogeneity, and spreadability.
4. To assess the **organoleptic characteristics** of the formulated gel including color, appearance, texture, and odor.
5. To determine the **stability** of the formulated herbal hand sanitizer gel under different storage conditions.
6. To investigate the role of phytoconstituents present in *Clitoria ternatea* responsible for its antimicrobial and antioxidant activities.

III. NOVELTY OF THE STUDY

A significant novelty of this research lies in the **incorporation of Butterfly Pea Flower infusion into a hand sanitizer gel formulation**. Butterfly pea flower is rich in **anthocyanins, flavonoids, tannins, and phenolic compounds**, which possess strong antibacterial, antioxidant, and skin-protective properties.

The utilization of its herbal infusion as an active ingredient in sanitizer preparation represents an innovative approach toward the development of natural and safer hand hygiene products. The formulated sanitizer is designed as a **completely herbal and reduced-chemical formulation**, minimizing the harmful effects commonly associated with repeated use of synthetic sanitizers. The antioxidant-rich phytoconstituents present in *Clitoria ternatea* help protect the skin from oxidative stress and may contribute to soothing and conditioning effects during frequent application.

Another unique aspect of the study is the development of a sanitizer gel that combines **effective antibacterial activity with aesthetic appeal**, including natural coloration and pleasant herbal characteristics obtained from butterfly pea flower infusion. Unlike conventional sanitizers that primarily focus only on microbial reduction, the proposed formulation aims to provide **antimicrobial protection, skin compatibility, antioxidant benefits, and improved user acceptability** simultaneously. Furthermore, the study promotes the utilization of medicinal plants in personal hygiene formulations and supports the advancement of **eco-friendly, economical, biodegradable, and sustainable herbal healthcare products**. The integration of traditional herbal knowledge with modern formulation techniques highlights the innovative nature and practical significance of this research in the field of herbal cosmetics and pharmaceutical sciences.

ADVANTAGES OF HERBAL HAND SANITIZER GEL

- The herbal hand sanitizer gel containing Butterfly Pea Flower (*Clitoria ternatea*) is gentler on the skin compared to chemical or high alcohol-based sanitizers, which often cause excessive dryness, itching, and irritation after frequent use.
- The formulation contains natural phytoconstituents such as **flavonoids, anthocyanins, tannins, and phenolic compounds** that provide effective antibacterial action without relying entirely on harsh synthetic chemicals.
- Butterfly pea flower possesses strong antioxidant activity that helps protect the skin from **oxidative stress and environmental damage**, unlike conventional sanitizers that mainly focus only on microbial reduction.
- Herbal formulations are generally safer for repeated daily application and are less likely to damage the natural skin barrier compared to chemical sanitizers containing excessive alcohol and synthetic additives.
- Natural herbal ingredients reduce the possibility of adverse effects such as redness, burning sensation, and hypersensitivity reactions commonly associated with synthetic fragrances and preservatives.
- The herbal sanitizer gel is more environmentally sustainable because plant-based ingredients are biodegradable and produce less chemical pollution compared to synthetic formulations.
- Unlike chemical sanitizers that leave the skin rough and dehydrated, the herbal formulation may provide mild moisturizing and soothing effects, improving overall skin comfort.
- Herbal hand sanitizer gels can be prepared using easily available medicinal plants, making them cost-effective, culturally acceptable, and increasingly preferred by consumers seeking natural healthcare products.

IV. LITERATURE REVIEW

1. Study by Deshmukh et al. (2020)

Deshmukh and colleagues carried out research on the **formulation and evaluation of herbal hand sanitizer gel containing medicinal plant extracts**. The objective of their study was to develop a safer and skin-friendly alternative to synthetic alcohol-based sanitizers. Various herbal extracts possessing antimicrobial properties were incorporated into gel formulations and evaluated for physicochemical and antibacterial characteristics. The prepared herbal sanitizer gels showed acceptable **pH, viscosity, spreadability, homogeneity, and stability**. The antimicrobial studies confirmed effective inhibition of pathogenic microorganisms, indicating the therapeutic potential of plant-based sanitizers. The study also highlighted that herbal sanitizers caused comparatively less skin irritation and dryness than conventional alcohol-rich formulations. The researchers concluded that medicinal plant extracts could serve as promising natural antimicrobial agents in hand hygiene products. Their findings strongly support the concept of the present study, which focuses on the development of a herbal hand sanitizer gel containing butterfly pea flower infusion along with neem, tulsi, and aloe vera for enhanced antibacterial and moisturizing effects.

2. Study by Rai et al. (2021)

Rai and co-workers presented a comprehensive review on the **medicinal properties and therapeutic applications of Butterfly Pea Flower (Clitoria ternatea)**. The review described the phytochemical composition of the plant and discussed its wide range of pharmacological activities including antibacterial, antioxidant, anti-inflammatory, neuroprotective, antidiabetic, and wound-healing effects. The authors reported that butterfly pea flower contains significant amounts of **anthocyanins, flavonoids, alkaloids, glycosides, and phenolic compounds**, which are responsible for its medicinal activities. The antioxidant properties of the plant were found to protect biological tissues against oxidative stress and cellular damage. The antibacterial activity was attributed to the ability of phytochemicals to interfere with microbial cell membranes and metabolic pathways. The review emphasized the growing importance of *Clitoria ternatea* in pharmaceutical, cosmetic, and nutraceutical industries due to its natural origin and safety profile. The information provided by this study supports the rationale behind selecting butterfly pea flower as a major active ingredient in the present herbal hand sanitizer gel formulation.

3. Study by Ghosh et al. (2021)

Ghosh and colleagues reviewed the role of **natural antioxidants in herbal skincare formulations** and discussed their importance in protecting skin health. According to the study, herbal ingredients rich in antioxidants help reduce oxidative stress, inflammation, and microbial damage while improving skin hydration and barrier function. The researchers highlighted that plant-derived antioxidants such as flavonoids, phenolic compounds, and anthocyanins possess dual benefits by providing both therapeutic and cosmetic effects. The incorporation of antioxidant-rich herbal extracts into topical formulations was found to improve product efficacy and skin protection. The study also emphasized that herbal skincare products containing natural antioxidants are increasingly preferred by consumers because of their safety, reduced toxicity, and eco-friendly nature. These findings are highly relevant to the present research since butterfly pea flower infusion is rich in anthocyanins and flavonoids that contribute to antioxidant and skin-protective properties in the formulated hand sanitizer gel.

4. Study by Sharma et al. (2020)

Sharma and co-workers discussed the **importance of herbal sanitizers in modern healthcare** and evaluated the potential of medicinal plant-based sanitizing formulations. The study highlighted the

limitations associated with conventional alcohol-based sanitizers, including excessive skin dryness, irritation, and long-term damage to the skin barrier. The authors suggested that herbal sanitizers prepared using medicinal plant extracts could provide effective antimicrobial action along with additional benefits such as moisturizing, soothing, antioxidant, and anti-inflammatory effects. Herbal formulations were also considered more environmentally sustainable and biodegradable compared to synthetic sanitizers. The study concluded that the demand for herbal sanitizing products has increased significantly due to rising awareness regarding natural healthcare and skin safety. The researchers recommended further exploration of medicinal plants with antimicrobial properties for the development of innovative hand hygiene products. This study strongly supports the objective of the present research work, which aims to formulate a herbal hand sanitizer gel containing butterfly pea flower infusion as a natural antibacterial and skin-friendly alternative to chemical sanitizers.

5. Study by Jeyaraj et al. (2013)

Jeyaraj and co-workers investigated the **antibacterial activity of Clitoria ternatea flower extract** against various human pathogenic microorganisms. The study revealed that the flower extract exhibited significant inhibitory activity against both gram-positive and gram-negative bacteria due to the presence of bioactive phytoconstituents such as **flavonoids, anthocyanins, tannins, and phenolic compounds**. The researchers emphasized that the antioxidant and antimicrobial properties of butterfly pea flower make it suitable for pharmaceutical and topical applications.

The study further demonstrated that aqueous and ethanolic extracts of *Clitoria ternatea* showed considerable antibacterial potential against *Escherichia coli*, *Staphylococcus aureus*, and other bacterial strains. The findings support the use of butterfly pea flower infusion as a natural antibacterial ingredient in herbal formulations. The research provided scientific evidence regarding the therapeutic value of the plant and encouraged further development of herbal healthcare products using butterfly pea flower extracts.

This study forms an important basis for the present research work, where butterfly pea flower infusion has been incorporated into a hand sanitizer gel formulation for achieving effective antibacterial activity with improved skin compatibility.

V. MATERIALS AND METHODOLOGY

Formulation Table:

Sr. No.	Ingredient	F1	F2	F3	F4	F5
1	Butterfly Pea	1 g	1.5 g	2 g	2.5 g	3 g
2	Neem Extract	1 ml	2.5 ml	1 ml	1.5 ml	0.5 ml
3	Tulsi Extract	5 ml	6 ml	8 ml	7 ml	8 ml
4	Aloe Vera Gel	3 g	5 g	7 g	4.5 g	5.5 g
5	Glycerin	2 ml	2 ml	1.5 ml	1 ml	0.5 ml

6	Carbopol	0.01 g	0.02 g	0.03 g	0.01 g	0.005 g
7	Lemon Essential Oil	2 drops	1 drop	2 drops	2 drops	2 drops
8	Rosemary Oil (Preservative)	0.03 ml	0.03 ml	0.03 ml	0.03 ml	0.03 ml
9	Distilled Water	up to 30 ml	up to 30 ml	up to 30 ml	up to 30 ml	Up to 30 ml

DESCRIPTION OF INGREDIENTS



1. Butterfly Pea Flower (Clitoria ternatea)

Biological Name: *Clitoria ternatea*

Family: Fabaceae

Biological Source: Flower of *Clitoria ternatea*

Role in Formulation

- used as the primary **herbal antibacterial and antioxidant agent**.
- Removes excess oil and impurities from skin

Uses

- Anti-microbial agent
- Removal of dead cells and dirt.

2. Neem Leaves

Synonyms

- Neem
- Indian Lilac
- Margosa

Biological Source

- Dried leaves of *Azadirachta indica*.

Family

- Meliaceae

Chemical Constituents

- Nimbidin
- Azadirachtin
- Quercetin
- Nimbolide
- Flavonoids
- Tannins
- Essential oils

Role in Formulation

- Acts as antimicrobial and anti-acne agent
- Prevents bacterial growth on skin
- Reduces inflammation and irritation
- Protects skin from infection

Uses

- Treatment of acne and pimples
- Antifungal and antibacterial activity
- Skin purification
- Reduces itching and redness
- Antioxidant protection

3. Aloe Vera

Synonyms

- Aloe
- Ghritkumari
- Barbados Aloe

Biological Source

- Dried leaf pulp of *Aloe barbadensis* Miller.

Family

- Liliaceae

Chemical Constituents

- Aloin
- Aloe-emodin
- Vitamins A, C, and E
- Polysaccharides
- Amino acids
- Enzymes
- Minerals

Role in Formulation

- Provides moisturizing and soothing effect
- Hydrates skin tissues
- Reduces dryness and irritation
- Promotes skin repair

Uses

- Skin moisturizing
- Cooling and soothing effect
- Wound healing
- Reduction of skin inflammation
- Anti-aging effect
- Skin rejuvenation

4. Tulsi**Scientific Name**

- *Ocimum tenuiflorum*

Biological Source

- Leaves of *Ocimum tenuiflorum*.

Family

- Ocimum

Chemical Constituents

- Volatile oils
- Essential oils
- Tannins

Role in Formulation

- Provides cooling and refreshing effect
- Enhances fragrance of formulation

Uses

- Skin brightening
 - Anti-inflammatory activity
 - Cooling effect
 - Aromatic skin care applications
5. Glycerin served as a **humectant** to prevent skin dryness.
 6. Carbopol was used as the **gelling agent** for achieving suitable consistency.
 7. Lemon essential oil enhanced the formulation with **fragrance and mild antimicrobial action**.
 8. Rosemary oil functioned as a **natural preservative**.
 9. Distilled water was used as the **vehicle** to maintain the final volume of the formulation.

Formulation of Herbal Hand Sanitizer Gel

Step 1: Preparation of Gel Base

Required quantity of **Carbopol 940** was slowly dispersed in distilled water with continuous stirring to avoid lump formation. The dispersion was allowed to hydrate completely for 1–2 hours until a uniform gel base was formed.

Step 2: Preparation of Additives Mixture

Glycerin, methyl paraben, and propyl paraben were dissolved in a small quantity of warm distilled water. Ethanol or isopropyl alcohol was added gradually with gentle stirring. Rose water or essential oil was incorporated to improve fragrance and skin feel.

Step 3: Incorporation of Herbal Infusion

The prepared butterfly pea flower infusion was added slowly into the gel base with continuous stirring to ensure uniform distribution throughout the formulation.

Step 4: Adjustment of pH

Triethanolamine was added dropwise to neutralize Carbopol and adjust the pH of the formulation within the skin-compatible range (approximately pH 6–7). Continuous stirring resulted in the formation of a smooth and homogeneous gel.

Step 5: Final Packaging

The prepared herbal hand sanitizer gel was transferred into clean, sterilized, airtight containers and stored at room temperature for further evaluation studies.

Evaluation Parameters

1. Organoleptic Evaluation

The prepared formulation was visually inspected for:

- **Color**
- **Appearance**
- **Odor**
- **Texture**
- **Consistency**
- **Homogeneity**

2. pH Measurement

The pH of the formulated gel was determined using a calibrated digital pH meter. About 1 g of gel was dispersed in 10 mL distilled water and the pH was recorded at room temperature. The measurement was performed in triplicate.

3. Determination of Viscosity:

Viscosity of the formulation was measured using a **Brookfield Viscometer** at suitable spindle speed and temperature conditions. The viscosity value was recorded to evaluate the consistency and flow behavior of the gel.

4. Spreadability

Spreadability was determined by placing a small quantity of gel between two glass slides and applying a specific weight over the upper slide. The time required for the upper slide to move a certain distance was noted.

5. Washability

A small amount of gel was applied on the skin and washed with water to evaluate ease of removal and residue formation.

6. Homogeneity Test

The formulation was tested by visual inspection for the presence of aggregates, grittiness, and phase separation. A smooth and uniform appearance indicated good homogeneity.

7. Drying Time

The drying time was determined by applying a fixed quantity of sanitizer gel onto the skin surface and recording the time required for complete drying.

8. Stability Studies

The prepared formulation was subjected to stability studies under different storage conditions such as room temperature and refrigerated conditions for a specified period. The formulation was periodically evaluated for changes in:

- Color
- Odor
- pH
- Consistency
- Phase separation

9. Antimicrobial Activity test

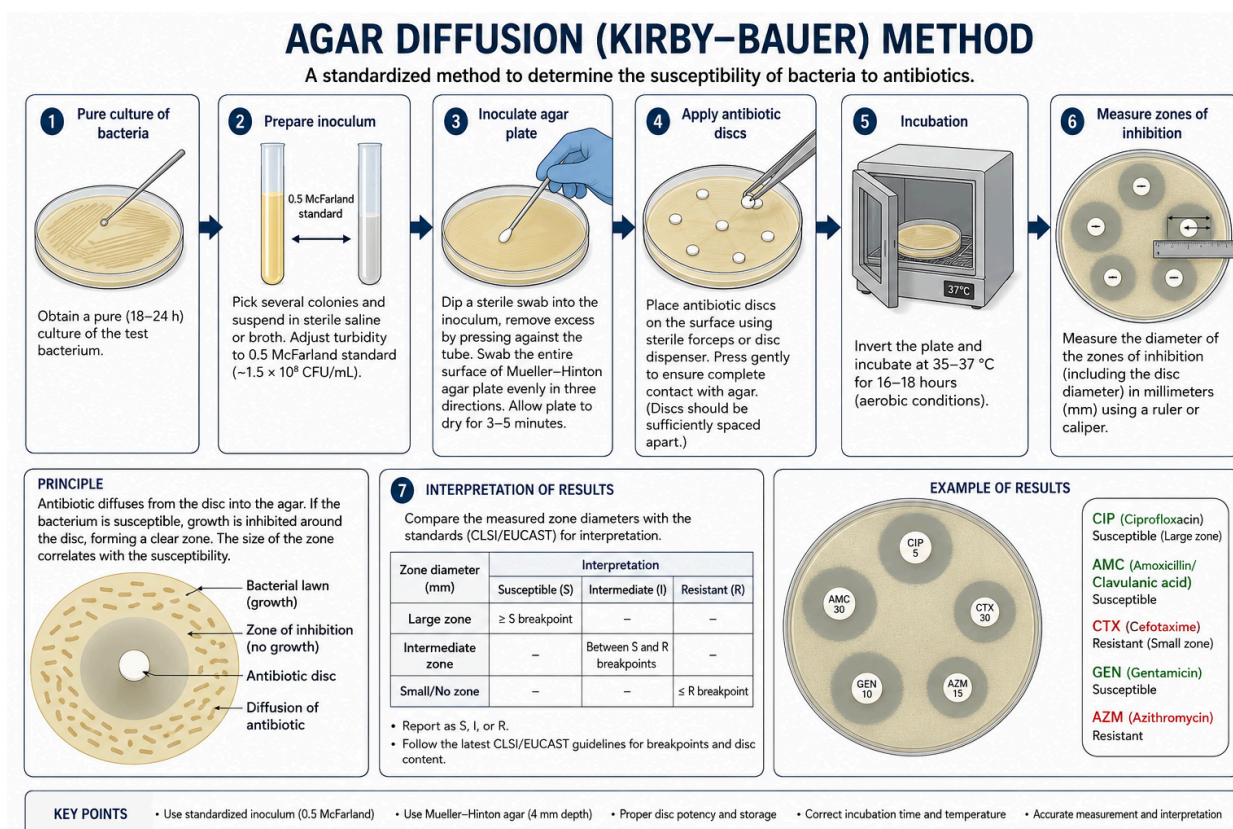
The antimicrobial activity of the prepared herbal hand sanitizer gel formulations was evaluated against *Escherichia coli* using the agar well diffusion method. The study was carried out to determine the antibacterial effectiveness of the prepared herbal hand sanitizer gel formulations and their ability to inhibit microbial growth on the skin surface.

The **agar well diffusion method** was employed for antimicrobial evaluation.

Procedure

- Nutrient agar plates were prepared and sterilized.
- Test microorganisms were inoculated uniformly on the agar surface.
- Wells were created using a sterile borer.
- Measured quantities of the formulated gel were introduced into the wells.
- The plates were incubated at 37°C for 24 hours.
- The **zone of inhibition** around the wells was measured in millimeters.

Greater zone of inhibition indicated better antibacterial activity of the formulation.



VI. RESULT & DISCUSSION

The formulated herbal hand sanitizer gels (F1–F5) were evaluated for their **appearance, color, odor, texture, consistency, and homogeneity**. All formulations exhibited a smooth gel-like consistency with satisfactory aesthetic appearance. The incorporation of Butterfly Pea Flower (*Clitoria ternatea*) infusion imparted a characteristic light blue to deep bluish coloration depending upon the concentration used in the formulation. The pleasant fragrance provided by lemon essential oil improved overall acceptability of the sanitizer gel.

Among all formulations, **F3 and F4** showed superior organoleptic characteristics with better smoothness, consistency, and visual appeal. Formulations containing lower concentrations of Carbopol exhibited slightly thinner consistency, whereas higher Carbopol concentration improved gel structure and spreadability. No grittiness, phase separation, or lump formation was observed in any formulation, indicating good compatibility among the ingredients.

The attractive natural coloration obtained from butterfly pea flower infusion eliminated the need for synthetic coloring agents, thereby improving the herbal and eco-friendly nature of the formulation. Aloe vera gel and glycerin contributed to the smooth texture and moisturizing feel of the product, making it suitable for repeated use without causing excessive dryness.

The pH of all formulations was found within the acceptable skin-compatible range of approximately **5.8–6.9**, which is considered suitable for topical application. Maintaining pH close to skin pH is essential to minimize irritation and preserve the natural protective barrier of the skin. The addition of triethanolamine effectively neutralized Carbopol and helped maintain gel stability. Formulations containing higher quantities of herbal extracts showed slight variation in pH due to the presence of phytoconstituents such as flavonoids and phenolic compounds. However, the observed pH values remained within acceptable limits.

Viscosity plays an important role in determining the application properties and stability of gel formulations. The prepared formulations exhibited moderate to good viscosity depending upon the concentration of Carbopol used.

Formulations F2 and F3 containing relatively higher concentrations of Carbopol demonstrated better gel consistency, improved thickness, and desirable flow characteristics. F4 showed comparatively lower viscosity due to reduced Carbopol concentration, resulting in a thinner gel structure. The incorporation of aloe vera gel also contributed to enhanced consistency and smooth texture. Proper viscosity is essential for easy dispensing, better retention on the skin surface, and uniform spreading during application. The results indicated that the formulated herbal sanitizer gels possessed satisfactory rheological characteristics suitable for topical use.

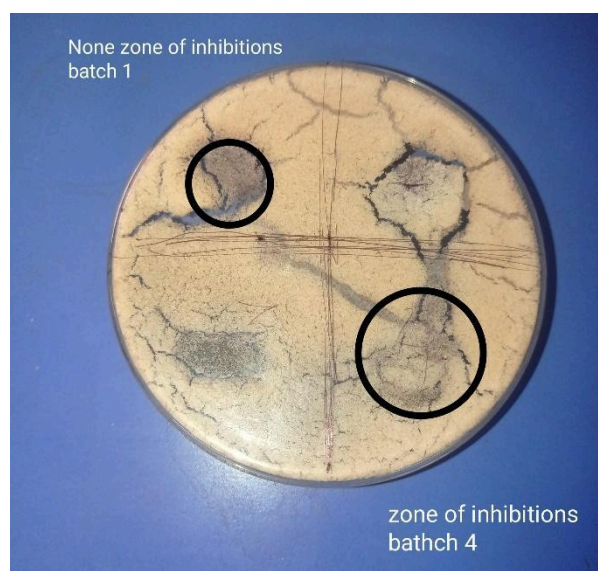
Spreadability is an important parameter that determines the ease of application of the formulation on the skin surface. All formulations exhibited good spreadability due to the balanced composition of Carbopol, glycerin, aloe vera gel, and distilled water. Formulations with moderate viscosity demonstrated superior spreading behavior compared to highly viscous gels. F3 showed optimum spreadability because of the appropriate balance between gelling agent and liquid components. Good spreadability ensures uniform distribution of antibacterial agents over the skin surface, thereby improving antimicrobial effectiveness. The presence of glycerin and aloe vera gel enhanced smoothness during application and prevented the formation of sticky residue after use. The results confirmed that the prepared formulations possessed acceptable application properties and consumer-friendly characteristics.

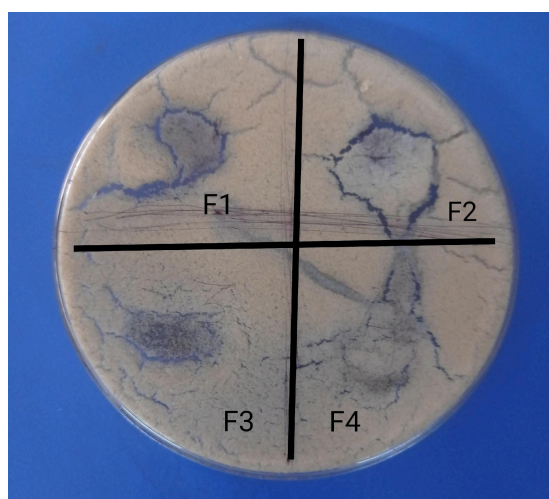
All prepared formulations were found to be **homogeneous** without the presence of visible particles, aggregates, or phase separation. Proper mixing and uniform incorporation of herbal ingredients resulted in stable gel formulations with smooth texture. **Washability studies** indicated that the gels could be easily removed from the skin surface without leaving excessive residue or oily sensation. Aloe vera gel and glycerin contributed to skin softness after washing, unlike many conventional alcohol-based sanitizers that often leave the skin dry and rough. The homogeneity and washability results demonstrated the physical stability and suitability of the formulations for routine hand hygiene applications.

Drying time is an important factor influencing the convenience and user compliance of hand sanitizer products. The formulated herbal hand sanitizer gels showed satisfactory drying characteristics when applied to the skin surface. Formulations containing higher water content required slightly longer drying time, whereas formulations with balanced gel consistency exhibited rapid absorption and comfortable after-feel. The sanitizer gels dried uniformly without producing stickiness or excessive residue. The incorporation of aloe vera gel and glycerin helped maintain skin hydration even after drying. Compared to highly alcohol-based sanitizers, the herbal formulations demonstrated improved skin comfort and reduced post-application dryness.

The stability study was carried out under room temperature and refrigerated conditions for a specified storage period. The formulations were periodically observed for changes in color, odor, consistency, pH, and phase separation. No significant changes were observed in the physical appearance or consistency of the formulations during the study period. The herbal gels retained their characteristic blue coloration and pleasant fragrance, indicating good stability of the incorporated herbal ingredients. The pH remained relatively constant throughout the storage period, suggesting chemical stability of the formulation. No microbial contamination or phase separation was observed, indicating satisfactory preservation and compatibility among ingredients. These findings confirmed that the prepared herbal hand sanitizer gels possessed acceptable physical and chemical stability suitable for practical usage and storage.

The zone of inhibition observed around the wells confirmed the **antibacterial potential** of the formulations. Formulation F1 showed a zone of inhibition of 10 mm, indicating moderate antibacterial activity. Formulation F2 exhibited an inhibition zone of 11 mm, while F3 showed 12 mm indicating improved antimicrobial action. Among all formulations, F4 exhibited the maximum zone of inhibition of 15 mm against *Escherichia coli*, indicating good antimicrobial activity.





Butterfly pea flower contains bioactive compounds such as **anthocyanins, flavonoids, and phenolic constituents**, which contribute significantly to antibacterial activity. Neem and Tulsi further enhanced antimicrobial effectiveness due to their well-established medicinal properties. Among all formulations, **F4 showed the highest antibacterial activity**, which may be due to the optimum balance of herbal extracts and gel consistency allowing better diffusion of active constituents. The results demonstrated that the developed herbal hand sanitizer gel can effectively inhibit bacterial growth and may serve as a natural alternative to chemical sanitizers.

Sr. No.	Parameter	F1	F2	F3	F4	F5
1	Colour	Pale blue	Light blue	Sky blue	Blue	Dark blue
2	Odour	Pleasant herbal	Mild Herbal	Strong herbal	Mild aromatic	Pleasant aromatic
3	Viscosity	Good consistency	Good consistency	Thick consistency	Excellent consistency	More thick consistency
4	pH	6.8	6.7	6.3	6.9	6.8
5	Spreadability	Good	Very good	Very good	Excellent	Very good
6	Stability	Stable	Stable	Stable	Stable	Colour changed observed

7	Texture	Smooth	Smooth	Fine and Smooth	Fine and smooth	Fine and smooth
8	Washability	Moderately Washable	Washable	Easily washable	Easily washable	Moderately washable
9	Anti-microbial activity	Moderate	Moderate	Good	Excellent	Very good

The present study successfully formulated and evaluated an **herbal hand sanitizer gel containing Butterfly Pea Flower infusion** as a natural antibacterial agent. The incorporation of multiple herbal ingredients provided enhanced antimicrobial activity along with improved skin compatibility and moisturizing properties. The results demonstrated that the formulation possessed desirable physicochemical characteristics including acceptable pH, good homogeneity, suitable viscosity, satisfactory spreadability, easy washability, and adequate stability. Unlike conventional alcohol-based sanitizers that frequently cause skin dryness and irritation, the developed herbal formulation offered a soothing and moisturizing effect due to the presence of aloe vera gel and glycerin. The antibacterial study confirmed the effectiveness of the herbal sanitizer against selected bacterial strains, supporting the therapeutic potential of medicinal plant-based sanitizing products. The natural coloration and antioxidant-rich phytoconstituents of butterfly pea flower further improved the uniqueness and cosmetic acceptability of the formulation. Overall, the study suggests that the formulated herbal hand sanitizer gel may serve as a safe, effective, economical, eco-friendly, and skin-friendly alternative to synthetic hand sanitizers for maintaining proper hand hygiene and preventing microbial infections.

VII. CONCLUSION

The present research successfully formulated and evaluated a **herbal hand sanitizer gel containing Butterfly Pea Flower (Clitoria ternatea) infusion** as a natural antibacterial agent. The study demonstrated that medicinal plant-based ingredients can be effectively utilized in the preparation of safe, effective, and skin-friendly sanitizing formulations with enhanced therapeutic and cosmetic benefits.

The prepared formulations showed satisfactory physicochemical characteristics including appropriate pH, good homogeneity, acceptable viscosity, enhanced spreadability, suitable drying time, and excellent stability. The incorporation of aloe vera gel and glycerin provided moisturizing and soothing effects, which helped overcome the common issue of skin dryness associated with repeated use of chemical hand sanitizers.

The antibacterial evaluation confirmed that the formulated herbal sanitizer possessed significant antimicrobial activity against selected pathogenic bacteria. The observed antibacterial effect may be attributed to the presence of bioactive phytoconstituents such as **anthocyanins, flavonoids, tannins, phenolic compounds, and essential oils** present in *Clitoria ternatea*, neem, and tulsi extracts. The synergistic action of these herbal ingredients enhanced the effectiveness of the formulation while maintaining skin compatibility. Among the prepared formulations, F3 was found to be the optimized formulation based on its superior antibacterial activity, desirable gel consistency, stability, and user-friendly application properties. The study also highlighted the additional advantages of herbal formulations such as

antioxidant activity, eco-friendliness, biodegradability, reduced chemical toxicity, and improved consumer acceptance.

Therefore, the developed herbal hand sanitizer gel may serve as a promising alternative to conventional synthetic sanitizers for maintaining proper hand hygiene and preventing microbial infections. The study supports the growing importance of herbal healthcare products and encourages further research on medicinal plant-based sanitizing formulations for commercial and pharmaceutical applications. Overall, the study highlighted the potential of medicinal plant-based formulations in the development of innovative herbal healthcare and personal hygiene products. The formulated herbal hand sanitizer gel demonstrated excellent antibacterial efficacy along with improved skin compatibility, natural composition, and consumer acceptability.

References

- [1] Alallam, A. E., et al. (2020). Herbal hand sanitizers as a potential substitute for alcohol-based sanitizers. *Journal of Pharmaceutical Research International*, 32(18), 120–128.
- [2] Anitha, T., & Usha, R. (2018). Evaluation of antibacterial activity of herbal extracts used in hand sanitizer formulations. *International Journal of Pharmaceutical Sciences and Research*, 9(4), 1452–1458.
- [3] Arumugam, G., et al. (2019). Phytochemical and pharmacological properties of *Clitoria ternatea*: A review. *International Journal of Research in Pharmaceutical Sciences*, 10(3), 2345–2353.
- [4] Bhattacharjee, S., & Das, A. (2021). Herbal cosmetics and their role in skin protection. *Asian Journal of Pharmaceutical and Clinical Research*, 14(2), 15–22.
- [5] Chusri, S., et al. (2014). Antibacterial activity of essential oils and medicinal plant extracts against skin pathogens. *BMC Complementary and Alternative Medicine*, 14(1), 105–112.
- [6] DebMandal, M., & Mandal, S. (2011). Antibacterial properties of plant essential oils and extracts. *Asian Pacific Journal of Tropical Biomedicine*, 1(1), 7–15.
- [7] Deshmukh, P. K., et al. (2020). Formulation and evaluation of herbal hand sanitizer gel containing medicinal plant extracts. *World Journal of Pharmaceutical Research*, 9(8), 1402–1415.
- [8] Dureja, H., et al. (2011). Cosmeceuticals: An emerging concept. *Indian Journal of Pharmacology*, 37(3), 155–159.
- [9] Ghosh, P., et al. (2021). Natural antioxidants in herbal skincare formulations: Current perspectives. *Journal of Cosmetic Dermatology*, 20(5), 1420–1432.
- [10] Gupta, P., & Yadav, D. K. (2018). Formulation and evaluation of herbal antibacterial gel. *International Journal of Green Pharmacy*, 12(2), 90–96.
- [11] Harborne, J. B. (1998). *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. Springer Publications.
- [12] Jeyaraj, E. J., et al. (2013). Antibacterial activity of *Clitoria ternatea* flower extract against human pathogens. *International Journal of Pharmacy and Pharmaceutical Sciences*, 5(3), 453–456.
- [13] Khandelwal, K. R. (2008). *Practical Pharmacognosy: Techniques and Experiments*. Nirali Prakashan.
- [14] Kokate, C. K., Purohit, A. P., & Gokhale, S. B. (2010). *Pharmacognosy*. Nirali Prakashan.
- [15] Kumar, S., et al. (2020). Development and evaluation of herbal sanitizer using medicinal plants. *International Journal of Pharmaceutical Investigation*, 10(4), 452–458.
- [16] Mishra, A., & Dubey, V. (2016). Evaluation of antibacterial activity of herbal formulations against pathogenic bacteria. *Journal of Applied Pharmaceutical Science*, 6(5), 123–129.

- [17] Mukherjee, P. K. (2019). *Quality Control and Evaluation of Herbal Drugs*. Elsevier Publications.
- [18] Nair, R., et al. (2005). Antibacterial activity of medicinal plants against clinically important bacterial pathogens. *Turkish Journal of Biology*, 29(2), 41–47.
- [19] Pandey, A., & Tripathi, S. (2014). Concept of standardization, extraction, and phytochemical screening methods in herbal drugs. *Journal of Pharmacognosy and Phytochemistry*, 2(5), 115–119.
- [20] Patel, R. P., et al. (2011). Formulation and evaluation of topical gel preparations. *International Journal of Pharmaceutical Sciences Review and Research*, 9(2), 72–78.
- [21] Prasad, K., et al. (2012). Evaluation of antimicrobial activity of herbal extracts in topical formulations. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 3(4), 1102–1110.
- [22] Rai, V., et al. (2021). Medicinal properties and therapeutic applications of Butterfly Pea Flower (*Clitoria ternatea*): A review. *Journal of Herbal Medicine*, 28, 100438.
- [23] Sharma, A., et al. (2020). Herbal sanitizers and their importance in modern healthcare. *International Journal of Pharmaceutical Research and Applications*, 5(3), 210–218.
- [24] Singh, M., & Kaur, G. (2019). Formulation development and evaluation of herbal cosmetic gels. *Asian Journal of Pharmaceutical Research*, 9(1), 45–50.
- [25] Yadav, R., et al. (2022). Herbal-based antimicrobial formulations for personal hygiene applications. *Journal of Drug Delivery and Therapeutics*, 12(1), 95–103.