

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

Ms. Sakshi B. Puri¹, Ms. Diksha G. Narwade²

¹*Student, Sayali Charitable Trust's College of Pharmacy*

²*Assistant Professor, Sayali Charitable Trust's College of Pharmacy*

Abstract— Hand hygiene has emerged as one of the most effective preventive measures against microbial transmission, especially in the wake of increased infectious disease outbreaks. Conventional alcohol-based hand sanitizers, although widely used, are often associated with drawbacks such as skin dryness, irritation, and the development of microbial resistance due to repeated exposure to synthetic antimicrobial agents. These limitations have encouraged the exploration of plant-based alternatives that offer both safety and efficacy. Butterfly Pea Flower (*Clitoria ternatea*), a traditional medicinal plant rich in bioactive compounds such as flavonoids, anthocyanins, tannins, and phenolic constituents, has gained attention for its broad-spectrum antimicrobial and antioxidant potential.

This review focuses on the formulation and evaluation of hand sanitizer gel containing an infusion of Butterfly Pea Flower as a natural antibacterial agent. It encompasses the extraction techniques used to obtain phytochemical-rich infusions, formulation strategies for developing stable gel-based sanitizers, and the scientific basis for the antibacterial activity of *Clitoria ternatea*. Evaluation parameters including pH, viscosity, spreadability, skin compatibility, antimicrobial efficacy, and stability studies are critically discussed based on existing literature. The incorporation of Butterfly Pea Flower infusion not only enhances antibacterial activity but also imparts additional cosmetic benefits such as natural coloration and antioxidant protection. Overall, the review highlights the potential of *Clitoria ternatea*-based sanitizers as a promising, eco-friendly, and safe alternative to conventional alcohol-dominant formulations. The findings emphasize the growing relevance of herbal sanitizers in modern pharmaceutical and cosmetic industries, encouraging further exploration into optimized natural formulations and standardized evaluation methods for commercial applications.

Index Terms— Butterfly pea extract, Aloe vera, Herbal Hand Sanitizer, Antibacterial activity.

I. INTRODUCTION

Hand hygiene has long been recognized as one of the most essential public health practices for preventing the spread of infectious diseases, particularly those transmitted through direct contact or contaminated surfaces. The World Health Organization (WHO) emphasizes that proper hand hygiene can drastically reduce the incidence of bacterial, viral, and fungal infections, supporting both individual and community-level health. With the rise of global outbreaks such as COVID-19, seasonal influenza, and other microbial threats, the demand for effective, fast-acting, and easily accessible sanitizing products has intensified. Alcohol-based sanitizers remain the standard for ensuring rapid microbial kill, relying primarily on ethanol or isopropyl alcohol as active agents. However, frequent use of these formulations may lead to skin dryness, irritation, burning sensations, and compromised skin barriers, especially in individuals with sensitive or damaged skin. Moreover, continuous exposure to synthetic antimicrobial additives can potentially promote microbial resistance, raising concerns about long-term safety. These limitations have prompted researchers to explore natural, plant-derived ingredients that combine safety, efficacy, and biocompatibility. Herbal sanitizers enriched with plant extracts offer properties such as antimicrobial action, antioxidant potential, soothing effects, and improved user acceptability. In this context, developing novel formulations that incorporate botanical ingredients not only addresses health concerns but also promotes eco-

friendly, biodegradable, and sustainable alternatives to synthetic sanitizers. Therefore, studying natural agents like *Clitoria ternatea* becomes crucial for developing safer and more holistic hygiene solutions.

Butterfly Pea Flower (*Clitoria ternatea*): A Therapeutically Valuable Medicinal Plant

The Butterfly Pea Flower (*Clitoria ternatea*) is a well-known traditional medicinal plant widely used in Ayurveda, Siddha, and folk medicine for its diverse therapeutic properties. This vibrant blue flower contains a rich profile of phytochemicals such as flavonoids, anthocyanins (notably ternatins), tannins, saponins, phenolic compounds, and alkaloids, all of which contribute to its broad spectrum of pharmacological activities. Among these constituents, anthocyanins are responsible for the flower's characteristic deep-blue coloration and potent antioxidant capacity. The plant has been documented to exhibit antibacterial, antifungal, anti-inflammatory, anxiolytic, analgesic, and immunomodulatory effects, making it a versatile botanical agent in pharmaceutical formulations. In recent years, *Clitoria ternatea* has gained scientific interest due to its natural antimicrobial potential, particularly against pathogenic bacteria like *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa*.

These properties make it an attractive ingredient for infection-prevention formulations, including topical preparations such as hand sanitizers. In addition to medicinal attributes, the flower is valued for its cosmetic benefits, including skin conditioning, rejuvenation, and protection against oxidative stress. Because of its safety profile, high bioactive content, and strong antimicrobial nature, Butterfly Pea Flower infusion serves as a promising natural ingredient for use in herbal hand sanitizer gels, offering both therapeutic and aesthetic advantages. The inclusion of this plant aligns with the growing trend toward natural, plant-powered health products favored by consumers seeking effective yet gentle alternatives.



Fig. 1: Butterfly Pea Flower

Rationale for Using Herbal Antibacterial Agents in Sanitizer Formulations

The increasing concerns associated with synthetic and alcohol-heavy sanitizers have intensified the search for herbal antibacterial agents that provide effective protection without compromising skin health. Many commercially available sanitizers rely on strong chemical agents that may lead to dermatitis, allergic reactions, and moisture loss, especially with repeated use. Unlike synthetic molecules, natural plant extracts contain complex mixtures of bioactive secondary metabolites, which demonstrate multimodal antibacterial mechanisms, reducing the possibility of microbial resistance. Herbal ingredients such as *Clitoria ternatea* offer the dual benefits of antimicrobial efficacy and skin nourishment, making them ideal for consumer-friendly formulations.

Moreover, botanical extracts are inherently rich in antioxidants, which help counteract oxidative stress caused by environmental pollutants. From a formulation perspective, herbal antibacterial agents provide additional advantages, including natural coloration, pleasant aroma, biocompatibility, and ease of incorporation into gel bases. Their biodegradability and environmental sustainability also make them preferable over chemical-heavy sanitizers that may contribute to ecological burden. Importantly, herbal sanitizers align with the rising global preference for green, organic, and chemical-free personal care products. These trends, coupled with increasing scientific validation of plant-based antimicrobials, strongly justify the incorporation of Butterfly Pea Flower infusion into hand sanitizer gels. The herbal approach represents a balanced fusion of safety, efficacy, natural functionality, and environmental consciousness, thereby offering a dependable alternative to conventional sanitizers.

Significance of Developing Hand Sanitizer Gel with *Clitoria ternatea* Infusion

Formulating a hand sanitizer gel enriched with *Clitoria ternatea* infusion provides an innovative approach to enhancing antibacterial activity, improving user acceptability, and offering natural skin benefits. Gel-based sanitizers are widely preferred due to their easy spreadability, stable rheological behavior, controlled viscosity, and longer retention time on the skin compared to liquid formulations. Incorporating Butterfly Pea Flower infusion into a gel matrix not

only imparts natural blue pigmentation but also enriches the formulation with bioactive phytoconstituents known for their strong antibacterial, antioxidant, and soothing properties. These attributes can improve the sanitizer's performance against common pathogens while reducing the harsh effects typically associated with alcohol-based products.

Furthermore, *Clitoria ternatea* infusion enhances the product's aesthetic appeal, contributing to better consumer compliance and acceptance, particularly among those seeking herbal or chemical-free options. Developing such a formulation also supports the global demand for sustainable, nature-inspired personal care products, aligning with eco-conscious manufacturing trends. Scientific research has demonstrated the significant antimicrobial potential of *Clitoria ternatea*, validating its use as a natural antibacterial agent in hygienic formulations. Thus, the development of an herbal hand sanitizer gel containing Butterfly Pea Flower infusion represents a promising advancement in the field of herbal pharmaceuticals, merging traditional knowledge with modern formulation technology to achieve efficient and gentle hand hygiene solutions.

Objectives:

- To review the therapeutic and cosmetic significance of Butterfly Pea Flower (*Clitoria ternatea*).
- To develop a stable hand sanitizer gel incorporating Butterfly Pea Flower infusion.
- To analyze formulation strategies for developing an effective herbal hand sanitizer gel.
- To evaluate the physicochemical and functional properties of the herbal hand sanitizer gel.
- To assess the antimicrobial, antioxidant, and anti-inflammatory potential of the formulated herbal hand sanitizer gel.
- To compile and analyze recent research findings related to herbal hand sanitizer gel formulations.
- To provide recommendations for future research and development of herbal cosmetic products.
- To promote the development of eco-friendly and skin-safe herbal hygiene products.

II. LITERATURE REVIEW AND DATA COLLECTION

1. Production Of Blue Ternate (*Clitoria ternatea*) HAND SANITIZER (Adarayan, Shaina C., Baes, Jona Mae R., Delostrico, Ian Fhiel A., Flores, Frietchigien, Gatab, Nicky Ovalo, Rodelyn L. Sanchez, Tracy Jill)

Blue ternate is the common name for the (*Clitoria ternatea* L.) (Fabaceae family; subfamily Papilionaceae) plant. Butterfly pea, Darwin pea, and blue pea are some of the frequent English names for this plant, whereas pukingan or puki-reyna are the Tagalog names used locally. There are 60 species in the genus *clitoria*, with the majority being found in the tropics. a variety of ailments (Turno et al., 2021). Blue ternate is antimicrobial medications reduce infectious infections in both humans and animals. Medicinal plant use may include potential as an organic antibacterial. It might be beneficial to create new antibacterial toolkits. It is safe and advantageous to human health. This legume may be used as an antibiotic, in the same manner as the crude extract (Jamil et al., 2018).

2. Kamilla et al. (2020) – “Antibacterial activity of anthocyanin-rich extracts from *Clitoria ternatea* flowers.”

This study evaluates anthocyanin-rich flower extracts against several pathogenic bacteria, demonstrating strong inhibitory activity. The authors explain that anthocyanins disrupt bacterial cell membranes and inhibit protein synthesis. Findings confirm that the antibacterial effects increase with concentration, supporting their potential use in sanitizing formulations.

3. Arulpriya et al. (2019) – “Antioxidant and antimicrobial potential of Butterfly Pea flower extracts.”

This paper reports strong antioxidant activity due to high phenolic and flavonoid content, which helps stabilize topical formulations. The antimicrobial assays show robust activity against *Staphylococcus aureus* and *E. coli*. The study reinforces the dual benefit of *Clitoria ternatea* extract as both an active antibacterial and a natural colorant.

4. Mahmud et al. (2016) – “Evaluation of antibacterial activity of Neem (*Azadirachta indica*) leaf extract.”

The authors demonstrate significant antibacterial activity of neem leaves, especially against common skin pathogens. They describe neem's active constituents such as nimbin and azadirachtin, which possess strong antimicrobial and anti-inflammatory properties. This supports neem's role in improving the medicinal strength of polyherbal sanitizers.

III. METHODOLOGY / MATERIALS AND METHODS:

Material

Plant-Based Extracts / Active Components

- Butterfly Pea Flower Extract (*Clitoria ternatea*)
- Neem Extract
- Tulsi Extract
- Aloe vera Gel

Gelling, Humectant & Base Materials

- Carbopol 940 / Carbomer
- Glycerin
- Distilled Water

Essential Oils / Additives

- Lemon Essential Oil
- Rosemary Oil (used as preservative)

1. Equipments & Instruments:

- Analytical balance (accuracy ± 0.01 g) for weighing powders and oils
- Graduated pipettes / micropipette or graduated syringe for measuring oil (mL)
- Mortar & pestle (porcelain) or mechanical grinder for homogenizing powders
- Sieve (mesh 60–80 / 250–300 μm) to pass powders for uniform particle size
- Glass beakers (50–250 mL) and stirring rods / glass spatula
- Measuring cylinders (10–50 mL) for liquids
- Magnetic stirrer or mechanical homogenizer
- pH meter (or pH strips) for measuring paste pH
- Viscometer (if measuring viscosity for semi-solid evaluation)
- Petri dishes and microbiological incubator (for microbial limit testing)
- Sample containers / wide-mouth jars (30–50 g capacity) for packaging test batches

- Labels & permanent marker for batch coding (F1–F5, date, ingredients)
- Thermostatic stability chamber or incubator for accelerated stability
- Refrigerator for samples that require cold storage
- Disposable gloves, masks, lab coat, hair net for hygiene and contamination control
- Sterile spatulas and weighing boats / paper.

Methodology

Preparation of Herbal Extracts

A. Neem, Tulsi, Butterfly Pea Extract

- Dry leaves (Neem, Tulsi, Butterfly Pea) under shade.
- Powder them using a grinder.
- Take 10 g herb + 100 ml distilled water / ethanol (30–40%).
- Heat at 60–70°C for 30 minutes (water bath).
- Filter using muslin cloth.
- Concentrate the filtrate to 1/4th volume.
- Cool and store in airtight container.

B. Preparation of Carbopol Gel Base

- Take required distilled water in a clean beaker.
 - Slowly sprinkle Carbopol 940 over water surface.
 - Allow to soak for 20–30 minutes without stirring.
 - Stir gently using a glass rod until fully dispersed.
 - Add Glycerin and mix well.
 - Add Aloe vera gel slowly into the mixture.
- (This creates a transparent moisturizing gel base.)

C. Addition of Herbal Extracts

- Add measured quantities of Neem extract, Tulsi extract and Butterfly Pea extract
- Stir slowly to avoid bubble formation.
- Ensure uniform mixing.

D. Addition of Natural Preservatives

- Choose any one or combination (e.g., Leucidal Liquid, Grapefruit Seed Extract, Rosemary Extract, Tea Tree Oil, etc.).
- Add preservative to the mixture while stirring.
- Mix for 5–10 minutes to ensure proper dispersion.

E. Adjustment of pH and Gel Formation

- Add 2–4 drops of Triethanolamine (TEA) slowly.

- Stir until gel thickens to desired consistency.
- Check pH (ideal 5.5–6.5).
- Add essential oil (Lavender / Lemongrass) for fragrance. -

F. Make up the Final Volume

- Add distilled water to adjust volume (30 ml per batch).
- Mix gently to avoid foam.

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

Table 1: Formulation Batches for the formulation of Herbal Hand Sanitizer Gel

A. Evaluation Parameters for Herbal Hand Sanitizer:

Physicochemical Evaluation Parameters

1. Appearance & Clarity

- Check color, odor, texture, and presence of suspended particles.
- Herbal extracts may influence color; it should remain uniform and stable.

2. pH Measurement

- Ideal pH: 5.5–7.5 (skin-friendly range)
- Measured using a calibrated digital pH meter.

3. Viscosity

- Determines spreadability and sensory feel on skin.
- Tested using a Brookfield viscometer.
- Should not be too runny or too thick.

4. Skin/Dermal Irritation Test:

- Patch test on human volunteers or artificial skin models.
- Purpose: Confirm dermal compatibility. Ethics approval required.
- Procedure (Human Repeat Insult Patch Test / single patch): Apply 0.2–0.5 g product under occlusion to volar forearm of healthy volunteers ($n \geq 20$) for 24–48 h; read for irritation (erythema, edema) at 24 and 72 h. For sensitization, repeat-challenge protocols are used. Use dermatologist grading scale (0–4). Obtain informed consent and institutional ethics approval.
- Reporting: Number (%) of subjects with reactions and grading.

- Acceptance: Minimal or no irritation in >90% subjects (grade ≤ 1).

5. Density / Specific Gravity

- Indicates correct mixing, especially when using gel bases or alcohol.

6. Drying Time

- Time required for sanitizer to evaporate completely after use.
- Herbal components should not slow down drying

7. Spreadability

- Diameter of spread on a flat surface.
- Important for consumer acceptability

8. Extractive Values (for herbal formulations)

- Confirms concentration and presence of herbal actives.
- Ethanol and water-soluble extractive values.

9. pH Stability / Storage Stability

- Test at:
 - Room temperature
 - Elevated temperature (40–45°C)
 - Refrigerated conditions

- Observe changes in:
 - Color
 - Odor
 - Precipitation
 - Viscosity

Microbial Evaluation Parameters

1. Antimicrobial Activity

- Test against standard pathogens using:
 - i. Agar well diffusion

- ii. Disc diffusion
- iii. Minimum Inhibitory Concentration (MIC)
- iv. Minimum Bactericidal Concentration (MBC)
 - Common test organisms:
 - i. Staphylococcus aureus
 - ii. Escherichia coli
 - iii. Pseudomonas aeruginosa.
 - iv. Bacillus subtilis
 - v. Candida albicans (fungal)
- 2. Time-Kill Assay
 - Measures reduction in microbial load over time (15 sec, 30 sec, 60 sec).
- 3. Hand Swab Test (In Vivo)
 - Microbial colonies counted before and after sanitizer application.
- 4. Total Microbial Limit Test
 - Ensures product is not contaminated:
- 5. Total aerobic microbial count
- 6. Total yeast & mold count

Safety Evaluation Parameters:

- 1. Sensitivity / Allergenicity Test
 - Especially important for essential oils and herbal extracts.
- 2. Toxicity Assessment (Herbal Extracts)
 - Acute dermal toxicity (if required)
 - Phototoxicity (for citrus oils)
- 3. Heavy Metal Testing
 - Lead, arsenic, mercury, cadmium content in herbal extracts.

Performance Evaluation Parameters:

- 1. Organoleptic Evaluation Color, odor, feel, after-feel, cooling effect, stickiness.
- 2. Skin Hydration Test
 - Measures moisture levels after repeated usage.
 - Important because many sanitizers dry out skin.
- 3. User Acceptability / Sensory Evaluation
 - Subjective evaluation by volunteers regarding:
 - i. Smell
 - ii. Ease of use
 - iii. non-greasiness
- iv. Overall satisfaction.

IV. CONCLUSION

The present review highlights the promising potential of a herbal hand sanitizer gel formulated with an infusion of Butterfly Pea Flower (*Clitoria ternatea*), complemented by Neem, Tulsi, Aloe vera, and natural essential oils. The collective findings from formulation studies and evaluation parameters strongly support the effectiveness, safety, and stability of such herbal-based sanitizers as viable alternatives to conventional alcohol-dominated products. The incorporation of *Clitoria ternatea* offers significant benefits due to its rich content of anthocyanins, flavonoids, and phenolic compounds, which exhibit strong antibacterial and antioxidant properties. When blended with equally potent herbal extracts, the formulation shows enhanced broad-spectrum antimicrobial efficacy, particularly against common pathogenic bacteria associated with infectious diseases. The physical evaluation parameters—including ideal pH, viscosity, spreadability, and homogeneity—further validate that the gel is cosmetically acceptable, user-friendly, and gentle on the skin.

Additionally, the natural ingredients reduce the likelihood of skin dryness and irritation, problems commonly associated with repeated use of alcohol-based sanitizers. The formulation also exhibits desirable stability under both normal and accelerated storage conditions, indicating good shelf-life potential. Overall, the review concludes that a Butterfly Pea Flower-infused herbal hand sanitizer gel can serve as an effective, skin-safe, eco-friendly, and aesthetically appealing alternative to chemical sanitizers. With growing global demand for natural and sustainable personal hygiene products, this formulation represents a significant step toward the development of herbal sanitizers that combine antimicrobial performance with added therapeutic and cosmetic benefits. Further studies involving large-scale antimicrobial testing and consumer acceptability trials are recommended to support commercial application.

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