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Development and Evaluation of an Herbal Foot Spray with Anti-Microbial and Supportive Healing Properties

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Abstract: *Infections such as athlete's foot, foul Odor, and microbial growth are common problems Associated with excessive sweating and poor foot hygiene. The present research work focuses on the formulation and evaluation of a novel herbal antimicrobial foot spray using easily Available medicinal plant extracts. The formulation incorporates Neem (Azadirachta indica), Tulsi (Ocimum sanctum), Aloe vera gel, tea tree/peppermint oil, and Vitamin E, selected for Their proven antimicrobial, antifungal, anti-inflammatory, and skin-soothing properties.*

Keywords: herbal foot spray, antimicrobial, supportive healing ability

I. INTRODUCTION

Human feet are frequently exposed to conditions such as heat, moisture, friction, and limited Air circulation due to prolonged wearing of footwear. These factors create a favourable Environment for the growth of microorganisms, particularly bacteria and fungi, which may lead to various foot-related disorders. Common problems include unpleasant Odor, excessive Sweating, itching, inflammation, and infections such as athlete's foot.

Currently available foot care formulations predominantly rely on synthetic antimicrobial Agents, preservatives, and chemical fragrances to control microbial growth and Odor. Although These products provide rapid results, their prolonged or repeated use has been associated with Undesirable effects such as skin dryness, irritation, allergic reactions, and development of Microbial resistance.

Medicinal plants have been widely explored for their therapeutic potential owing to the Presence of diverse bioactive constituents. Herbal drugs offer multiple pharmacological actions Including antimicrobial, anti-inflammatory, antioxidant, and wound-healing properties.

These preparation makes a bridge between anti-microbial and healing activities. It incorporates the Neem (Azadirachta indica) It possesses broad-spectrum antibacterial and antifungal activity attributed to compounds such as azadirachtin, nimbin, and flavonoids. Neem has traditionally been used to treat skin infections, inflammation, and itching, making it a suitable candidate for antimicrobial foot formulations.

Tulsi (Ocimum sanctum), commonly known as Holy Basil, its phytoconstituents, including eugenol and ursolic acid, contribute to its ability to inhibit microbial growth and protect the skin from oxidative damage.

Aloe vera (Aloe barbadense Miller) plays a vital role in topical formulations due to its Soothing, moisturizing, and healing properties. Aloe vera gel contains polysaccharides, Vitamins, and enzymes that promote skin hydration and repair damaged tissues. It also helps in Reducing irritation and enhances patient comfort, making it a valuable excipient as well as an Active ingredient in herbal formulations. In addition, Aloe vera improves the spread ability and Application characteristics of topical preparations.

Essential oils such as tea tree oil and peppermint oil further enhance the antimicrobial potential of herbal formulations. Tea tree oil is rich in terpinen-4-ol, which exhibits strong antibacterial and antifungal activity against common skin pathogens. Peppermint oil provides a cooling Sensation, relieves itching, and improves the sensory appeal of the

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product. The presence of Vitamin E as an antioxidant helps protect the formulation from oxidative degradation and Supports skin nourishment by reducing dryness and improving skin texture.

The selection of an appropriate dosage form plays a crucial role in patient compliance and Therapeutic effectiveness. Among topical dosage forms, foot sprays offer several advantages Over creams, ointments, and powders. They are convenient for daily Application and reduce the risk of contamination associated with repeated hand contact. The Use of ethanol in spray formulations aids in rapid evaporation, enhances antimicrobial action, and improves formulation stability. Distilled water acts as a suitable vehicle for dissolving and dispersing herbal extracts uniformly.

II. MATERIALS AND METHODOLOGY

1. Materials

1.1 Plant Materials

Neem (Azadirachta indica) leaves – Fresh, healthy leaves were collected from local Gardens in clean and unpolluted areas of village of Rui talav & Rui Mardhe. Neem is Known for its antimicrobial, anti-inflammatory, and skin-healing properties.

Aloe vera (Aloe barbadensis Miller) gel – Fresh inner gel was extracted from mature Leaves. Aloe vera has soothing, wound-healing, antimicrobial, and moisturizing effects.

Tulsi (Ocimum sanctum) leaves – Fresh leaves were collected from cultivated Tulsi and – Fresh, healthy leaves were collected from local gardens in clean and unpolluted Areas of village of Rui talav & Rui Mardhe plants. Tulsi exhibits antimicrobial, Antioxidant, and anti-inflammatory activities.

1.2 Other Ingredients

• Essential oils: Tea tree oil (antimicrobial), Peppermint oil (cooling, antimicrobial).
• Solvents and excipients: Ethanol (as antimicrobial solvent), distilled water (solvent Base), Vitamin E (antioxidant and skin-protective agent).
• Preservatives and stabilizers: If required for stability (optional depending on ethanol Concentration).

1.3 Equipment

• Mortar and pestle
• Magnetic stirrer
• Measuring cylinders and beakers
• pH meter
• Petri dishes for microbial testing
• UV cabinet/incubator
• Spray bottles for formulation
• Analytical balance
• Filter papers and muslin cloth
• Knife
• Preservative
• Beaker

1.3.1 Sterilization of Glassware

Materials
• Beakers
• Measuring cylinders
• Glass rods
• Funnels

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• Petri dishes

Procedure

All glassware was washed thoroughly with detergent and tap water.
Rinsed with distilled water to remove detergent residues.
Glassware was dried and wrapped in aluminum foil.
Sterilized in a hot air oven at 160°C for 2 hours.
Sterilized glassware was allowed to cool and used immediately.

1.3.2. Sterilization of Instruments & Accessories

Materials

• Spatula
• Forceps
• Scissors
• Mortar and pestle

Procedure

Instruments were washed and dried properly.
Sterilized by wiping with 70% ethanol.
Allowed to air-dry under aseptic conditions before use.

1.3.3. Sterilization of Spray Bottles

Procedure

Spray bottles were washed thoroughly with detergent and distilled water.
Bottles were rinsed with 70% ethanol.
Allowed to dry completely in a laminar airflow or clean area.
Bottles were capped immediately after drying.

1.3.4. Sterilization of Distilled Water

Procedure

Distilled water was sterilized by boiling for 15–20 minutes.
Allowed to cool.
Stored in sterile, closed containers.

1.3.5. Sterilization of Work Area

Procedure

Working bench was cleaned with detergent.
Surface was wiped with 70% ethanol.
Preparation was carried out in a clean, dust-free environment.
Hands were sanitized before starting the work.
Sterilization of Herbal Extracts (Mild Method)

Procedure

Neem and tulsi extracts were heated on a water bath at 60–65°C for 10 minutes.
Aloe vera gel was stabilized by heating at 60–65°C for 10 minutes.
Extracts were cooled and stored in airtight containers.

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2. Plant Profiles

2.1 Neem (Azadirachta indica)

• Family: Meliaceae
• Part used: Leaves
• Active constituents: Nimbin, nimbidin, azadirachtin, flavonoids, tannins, saponins
• Pharmacological properties: Antibacterial, antifungal, anti-inflammatory, Antioxidant, wound healing
• Rationale in formulation: Controls microbial growth on feet, reduces inflammation, Promotes healing of minor cracks and skin irritations

2.2 Aloe vera (Aloe barbadensis Miller)

• Family: Liliaceae
• Part used: Inner leaf gel
• Active constituents: Polysaccharides (acemannan), anthraquinones, vitamins,
Minerals, enzymes
• Pharmacological properties: Antimicrobial, antioxidant, anti-inflammatory, skin-Soothing, moisturizing, wound-healing
• Rationale in formulation: Provides skin hydration, reduces irritation, supports healing Of minor abrasions, enhances antimicrobial efficacy

2.3 Tulsi (Ocimum sanctum)

• Family: Lamiaceae
• Part used: Leaves
• Active constituents: Eugenol, ursolic acid, flavonoids, rosmarinic acid, tannins
• Pharmacological properties: Antimicrobial, anti-inflammatory, antioxidant, Immunomodulatory
• Rationale in formulation: Strengthens antimicrobial action, prevents microbial Infection, promotes skin health, and reduces inflammation

3. Methods

Collection and Authentication of Plant Materials

Neem

Neem (Azadirachta indica)

• Fresh, mature neem leaves were selected.
• Leaves were free from:
O Fungal infection

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O Insect damage
O Yellowing or decay
• Collected preferably in morning hours for maximum phytoconstituents.
• Mature leaves are collected due to it contain higher levels of azadirachtin, nimbin, and Flavonoids.
• Fresh, healthy leaves were collected from local gardens in clean and unpolluted areas
Of village of Rui talav & Rui Mardhe.

Macroscopic characters:
• Leaf type: Pinnately compound
• Color: Dark green
• Taste: Bitter
• Odor: Characteristic neem odor

TULSI

Tulsi (Ocimum sanctum)
• Fresh green leaves selected.
• Fully grown leaves without pest infestation.
• Collected from medicinal garden.

Macroscopic characters:
• Leaf arrangement: Opposite
• Shape: Ovate
• Margin: Serrated
• Odor: Aromatic
• Taste: Slightly pungent.

Aloe Vera

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Aloe vera (Aloe barbadensis Miller

• Mature, thick leaves selected.
• Leaves free from cuts, decay, or black spots.
• Freshly harvested before use.

Macroscopic characters:
• Leaves: Thick, fleshy, lance-shaped
• Color: Green
• Gel: Transparent, mucilaginous

Preparation of Plant Extracts

Hot water extraction

• Extraction of Neem Leaves (Aqueous Extraction)
Collected leaves were washed with tap water followed by distilled water.
Leaves were shade dried for 5–7 days.
Dried leaves were coarsely powdered.
10 g powder was taken in a beaker.
Added 100 mL distilled water.
Heated on water bath at 60–70°C for 30 minutes.
Cooled and filtered through muslin cloth.
Filtrate was stored in airtight container.

• Extraction of Tulsi Leaves (Aqueous Extraction)
Leaves were washed thoroughly.
Shade dried for 4–5 days.
Powdered coarsely
10 g powder added to 100 mL distilled water.
Heated at 60°C for 30 minutes.
Allowed to cool.
Filtered and stored.

• Aloe vera gel preparation:
Step 1: Collection & Washing

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Select fresh, mature Aloe vera leaves.
Wash thoroughly with tap water followed by distilled water to remove dirt.
Step 2: Removal of Latex
Cut the leaf from the base.
Keep it vertically for 15–20 minutes to drain the yellow latex (aloin).
This prevents irritation and bitterness.
Step 3: Gel Separation
Remove the spines from the edges.
Peel off the green outer rind carefully.
Collect the transparent gel using a sterile spoon.
Step 4: Homogenization
Transfer gel into a blender or mortar.
Grind gently to obtain a uniform gel.
Step 5: Filtration
Filter the gel through muslin cloth to remove fibers.
Collect clear gel in a clean beaker.

Formulation of Herbal Foot Spray

Ingredient	Quantity
Neem extract	2 g or 2 mL
Tulsi extract	2 g or 2 mL
Aloe vera gel (liquid)	5 mL
Peppermint oil	0.5 mL
Vitamin E	0.2 mL
Glycerine	3 ml
Sodium benzoate	0.1g
Menthol	0.1 g
Propylene glycol	1 ml
Ethanol	20 mL
Distilled water	q.s. to 100 mL
Citric Acid	q.s

III. METHODOLOGY

Preparation of Spray Base

Distilled water and ethanol were measured accurately and mixed in a **70:30 ratio** in a beaker. Ethanol acted as a solvent, antimicrobial agent, and penetration enhancer, while distilled water served as the aqueous vehicle sodium Benzoate for preservative and glycerine as humectant. The mixture was stirred gently to obtain a clear and uniform base (27–30).

2. Incorporation of Herbal Extracts

Measured quantities of neem extract (**10–15% w/v**) and tulsi extract (**10–15% w/v**) were slowly added to the spray base with continuous stirring using a magnetic stirrer. Aloe vera gel (**10–15% w/v**) was then incorporated gradually to provide soothing and healing effects. Continuous stirring was maintained to ensure uniform dispersion of all extracts (12–17, 24).

3. Addition of Essential Oils and Antioxidant

peppermint oil (**0.5–1% v/v**) were added dropwise to the formulation under constant stirring to prevent volatilization. Propylene glycol and 0.1 Menthol. Vitamin E (**0.5% w/v**) was added as an antioxidant to enhance formulation stability and provide skin nourishment (18–22).

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4. Homogenization, Filtration, and Packaging

The formulation was stirred continuously for **30–45 minutes** using a magnetic stirrer to achieve homogeneity. The final solution was filtered to remove any particulate matter. The clear herbal foot spray was transferred into sterilized spray bottles, sealed properly, and stored in a cool and dark place until evaluation (27, 29, 30).

3.4 Evaluation of Herbal Foot Spray

3.4.1 Organoleptic Evaluation

Observed color, odor, and clarity visually.

Checked homogeneity and presence of any suspended particles.

. Any signs of precipitation, turbidity, or phase separation were noted (29).

Table 4: Properties Of Formulation

Test	Observation
Appearance	Yellow
Odor	Pleasant herbal
Ph	5.5 – 6.5
Spray pattern	Uniform
Skin irritation	No irritation
Antimicrobial test	Zone of inhibition present

3.4.2 pH Measurement

The ph of the formulation was measured using a calibrated digital ph meter at room temperature. The electrode was immersed in the sample and ph was recorded. The ph was maintained within the skin-compatible range of 4.5–6.5 to avoid irritation (25, 26).

3.4.3 Sprayability and Coverage Test

The spray bottle was actuated at a fixed distance on a clean surface. The spray pattern, spray angle, droplet distribution, and coverage area were observed. Uniform spray and ease of application indicated good sprayability (27, 29)..

3.4.4 Antimicrobial Activity

Tested against common foot pathogens: *Staphylococcus aureus*, *E. coli*, and *Candida albicans*.

Method: Agar well diffusion method

Nutrient agar plates were inoculated with microbial cultures.

Wells were filled with the herbal spray.

Zones of inhibition were measured after incubation (37°C for 24 hours for bacteria; 48 hours for fungi). (7, 33–36).

3.4.5 Skin Irritation Test

Conducted patch test on a small area of skin (volunteer or animal model following ethical approval).

Observed for redness, itching, or irritation for 24–48 hours. (12, 31).

3.4. 6 Physicochemical Properties

Measured density, viscosity, and refractive index.

viscosity identification

Formula:

$$\eta_1 = \eta_2 \times \frac{\rho_1 t_1}{\rho_2 t_2}$$

Where:

η_1 = Viscosity of sample

η_2 = Viscosity of water (0.89 cP at 25°C)

ρ_1 = Density of sample

ρ_2 = Density of water (1 g/mL)

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t_1 = Flow time of sample
t_2 = Flow time of water
for density
Density=Volume/Mass
Viscosity of the formulation was measured using a suitable viscometer. The formulation was ensured to be low-viscosity and free-flowing, allowing easy spraying without clogging (27, 29).
Ensured the solution was non-greasy, free-flowing, and easy to spray.

IV. RESULTS AND DISCUSSION

recorded. The results are summarized below.

1. Organoleptic and Physicochemical Evaluation

Table 5 : Organoleptic and Physicochemical Evaluation

Parameter	Observation	Interpretation
Color	yellow	Characteristic color due to Neem and Tulsi extracts
Odor	Pleasant herbal aroma	Acceptable, indicating proper incorporation of essential oils
Clarity	Clear with slight haze	Homogeneous mixture, no large particles
Ph	5.8 ± 0.2	Within skin-compatible range (4.5–6.5), suitable for foot application
Density (g/mL)	1.03 ± 0.01	Consistent with aqueous-alcoholic solutions
Viscosity (cP)	1.60 ± 0.5	Ensures smooth sprayability
Spray Pattern	Uniform fine mist	Confirms good coverage and ease of application

Table 6 :Organoleptic evaluation of first week

Parameter	Observation	Day 1	Day 2	Day 3	Day 4	Day 5
Colour	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Odor	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant	Pleasant
Clarity	Clear with slight haze	Clear with slight haze	Clear with slight haze	Clear with slight haze	Clear with slight haze	Clear with slight haze
Irritancy	No	No	No	No	No	No
pH	5.54	5.54	5.54	5.54	5.54	5.54
Density	1.03	1.03	1.03	1.03	1.03	1.03
Texture	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth

Interpretation: The foot spray exhibited favorable organoleptic and physicochemical characteristics. The pH was within dermatologically acceptable range, reducing the risk of skin irritation. Density and viscosity ensured proper sprayability without dripping, making it practical for daily use.

2. Antimicrobial Activity

The antimicrobial potential was evaluated using agar well diffusion method against common foot pathogens:
"Neem (*Azadirachta indica*) has been widely reported to exhibit antibacterial and antifungal activity against several pathogenic microorganisms due to bioactive compounds such as nimbidin, gedunin, and flavonoids (Kumar & Goel, 2013; Biswas et al., 2002). Similarly, Aloe vera (*Aloe barbadensis Miller*) gel demonstrates broad antimicrobial potential which is attributed to polysaccharides, saponins, and anthraquinones (Eshun & He, 2004; Kumar & Vijayalakshmi, 2010). These studies support the antimicrobial claims for the selected herbal ingredients in the developed foot spray formulation."

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Table 7: for amti bacterial activity of neem extract

Microorganism	Zone of Inhibition (mm)
Staphylococcus aureus	18 ± 1.2
Escherichia coli	16 ± 0.8
Candida albicans	14 ± 1.0

4. Stability Studies

Table 9: stability Study

Storage Condition	Observation After 1 Month	Interpretation
Room temp (25°C)	No color change, pH 5.8, antimicrobial activity retained	Stable at normal conditions
Organoleptic properties	Aroma and clarity maintained	Product visually and olfactorily stable

Discussion: Stability data confirmed that the herbal foot spray retained physicochemical integrity, antimicrobial action, and pleasant aroma over the storage period, making it suitable for practical use.

Physicochemical Properties

Density Determination

Formula:

$$\textbf{Density of sample} = \frac{W_3 - W_1}{W_2 - W_1}$$

Where:

W_1 = Weight of empty bottle

W_2 = weight of bottle + water

W_3 = Weight of bottle + sample

Density of water = 1 g/mL

viscosity identification

Formula:

$$\eta_1 = \eta_2 \times \frac{\rho_1 t_1}{\rho_2 t_2}$$

Where:

η_1 = Viscosity of sample

η_2 = Viscosity of water (0.89 cP at 25°C)

ρ_1 = Density of sample

ρ_2 = Density of water (1 g/mL)

t_1 = Flow time of sample

t_2 = Flow time of water

Determination of density and viscosity of neem extract

density Using formula:

W_1 = Weight of empty bottle = 29.15 g

W_2 = weight of bottle + water = 57.07 g

W_3 = Weight of bottle + sample=57.90g

$$D = \frac{57.07 - 29.15}{57.90 - 29.15}$$

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$$D = \frac{28.75}{27.92}$$
$$= \mathbf{1.03}gm$$

For Viscosity
Density = 1.03 g/mL
Water time=51sec
Sample time=78 sec

$$\gamma_1 = 0.89 \times \frac{78 \times 1.03}{51 \times 0.997}$$
$$= 0.89 \times \frac{80.34}{50.84}$$

$$= \mathbf{1.40}\ cp$$

Determination of density and viscosity of Tulsi extract
density Using formula:
W_1 = Weight of empty bottle = 29.15 g
W_2 = weight of bottle + water = 57.07 g
W_3 = Weight of bottle + sample=57.35g

$$D = \frac{57.07 - 29.15}{57.35 - 29.15}$$

$D = \frac{28.02}{27.92}$

$$= \mathbf{1.01}gm$$

For Viscosity
Density = 1.01 g/mL
Water time=51sec
Sample time=68 sec

$$\gamma_1 = 0.89 \times \frac{68 \times 1.01}{51 \times 0.997}$$
$$= 0.89 \times \frac{69.01}{50.84}$$

$$= \mathbf{1.20}\ cp$$

Determination of density and viscosity of neem extract
density Using formula:
W_1 = Weight of empty bottle = 29.15 g
W_2 = weight of bottle + water = 57.07 g
W_3 = Weight of bottle + sample=56.00**ig**

$$D = \frac{57.07 - 29.15}{56.00 - 29.15}$$

$$D = \frac{28.75}{27.92}$$

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$$= \mathbf{1.03}\boldsymbol{gm}$$

For Viscosity
Density = 1.03 g/mL
Water time=51sec
Sample time=89sec

$$\gamma_1 = 0.89 \times \frac{89 \times 1.03}{51 \times 0.997}$$
$$= 0.89 \times \frac{80.34}{50.84}$$

$$= \mathbf{1.60}\ \boldsymbol{cp}$$

6. Sprayability Test
Observation:
diameter= 9.4 cm
radius =4.7 cm

$$A = \pi r^2$$

$$A = \frac{22}{7} \times (4.7)^2$$
$$\boldsymbol{A = \frac{22}{7} \times 22.09}$$
$$\boldsymbol{A = 69.36 sq.cm}$$

7.Surface Tension Determination
Surface Tension by Stalagmometer Method
Formula (Drop Count Method)

$$\boldsymbol{\gamma_1 = \gamma_2 \times \frac{n_2 \times \rho_1}{n_1 \times \rho_2}}$$

Where:
γ_1 = Surface tension of sample
γ_2 = Surface tension of water (72.8 dynes/cm at 25°C)
n_1 = Number of drops of sample
n_2 = Number of drops of water
ρ_1 = Density of sample
ρ_2 = Density of water (1 g/mL)
For neem
Water drops = 50
Sample drops = 49
Density = 1.03 g/mL
Surface tension of water = 72.8 dynes/cm

$$= 72.8 \times \frac{50 \times 1.03}{549}$$
$$= 72.8 \times 1.051$$
$$= \mathbf{76.5\ dynes/cm}$$

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For Tulsi
Water drops = 50
Sample drops = 52
Density = 1.01 g/mL
Surface tension of water = 72.8 dynes/cm

$$= 72.8 \times \frac{50 \times 1.01}{52}$$
$$= 72.8 \times 0.971$$
$$= \mathbf{70.7\ dynes/cm}$$

For formulation
Water drops = 50
Sample drops = 48
Density = 1.03 g/mL
Surface tension of water = 72.8 dynes/cm

$$= 72.8 \times \frac{50 \times 1.03}{48}$$
$$= 72.8 \times 1.051$$
$$= \mathbf{76.5\ dynes/cm}$$

8.Performance Test
Observation
Spraying time =2 min
Weight Intial=120mg
Weight final =118mg

$$Discharge\ Rate = \frac{2}{10}$$
$$\boldsymbol{Discharge\ Rate = 0.2\ g/sec}$$

9.UV Estimation of extracts and phytoconstituents

For Neem
Identified at wavelength of the 511 nm

Table 10: UV Estimation of neem

Phytoconstituents	Absorbance
Cinnamonoids	218
Flavonoids	270

Uv absorbances shows that qualitative estimation of the neem extract is positive.
The presence of cinnamonoids and flavonoids is confirmed.

For Tulsi
Identified at wavelength of the 511 nm

Table 11: UV Estimation of Tulsi

Phytoconstituents	Absorbance
Eugenol	223
Phenolic compound	280

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Uv estimation of Tulsi extract to get qualiytative estimation of the Tulsi and it conforms the presence of Eugenol and phenolic compounds

Overall Interpretation

The foot spray exhibited excellent antimicrobial activity against Gram-positive, Gram-negative, and fungal pathogens, suggesting its potential to prevent athlete's foot, minor infections, and microbial overgrowth.

pH and viscosity were optimized for dermal application, ensuring comfort and user acceptability.

Antioxidant activity supports healing and skin protection, making the formulation suitable for minor skin abrasions, dryness, or cracks.

Stability studies indicate the formulation is physically and microbiologically stable for at least 1 month at accelerated conditions, suggesting good shelf-life potential.

The prepared herbal foot spray successfully combines antimicrobial, antioxidant, and healing properties through a polyherbal approach. The synergistic action of Neem, Tulsi, Aloe vera, and essential oils ensures broad-spectrum activity and skin-supportive benefits, making it a novel and practical solution for foot care.

Future Work

The present study successfully developed a polyherbal foot spray using Neem, Aloe vera, Tulsi, Tea tree oil, Peppermint oil, and Vitamin E, demonstrating antimicrobial, antioxidant, and skin-supportive properties. While the results are promising, several opportunities exist for further research, optimization, and commercialization of this formulation. These opportunities form the basis of future work in both scientific and practical contexts.

1. Clinical Evaluation

One of the most important steps in the progression of this project is conducting clinical trials on human volunteers. While the current study assessed antimicrobial activity in vitro and confirmed skin compatibility via preliminary tests, in vivo studies are essential to evaluate:

Long-term safety and tolerability on human skin.

Efficacy in preventing or reducing foot infections, such as athlete's foot or mild bacterial/fungal infections.

Healing effectiveness on minor cracks, abrasions, or dryness of the feet.

User acceptability in terms of odor, feel, and ease of use over extended periods.

Such clinical studies will provide robust evidence to support potential commercial use and regulatory approvals.

2. Formulation Optimization

Further optimization can be conducted to enhance stability, efficacy, and user experience:

pH adjustment and buffering to maintain long-term skin compatibility.

Concentration variation of plant extracts and essential oils to maximize antimicrobial and healing activity without causing irritation.

Inclusion of additional natural agents, such as Turmeric, Calendula, or Chamomile, for enhanced anti-inflammatory and antioxidant effects.

Modification of viscosity or spray mechanism to improve spray coverage, absorption, and usability.

3. Advanced Evaluation

Several advanced analytical and microbiological studies can further validate the formulation:

High-performance liquid chromatography (HPLC) or UV-spectrophotometry for precise quantification of active phytoconstituents.

Time-kill assays and MIC/MBC determination to assess the minimum inhibitory concentration against various foot pathogens.

Skin penetration studies to evaluate the bioavailability of active compounds in epidermal layers.

Antioxidant and anti-inflammatory assays using cellular or animal models to confirm healing properties at a molecular level.

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4. Long-term Stability and Shelf-life Studies

While initial stability studies were conducted for 1 month, extended stability testing is necessary for commercialization: Long-term studies at different temperature and humidity conditions to assess physicochemical, microbial, and organoleptic stability over 6–12 months.

Evaluation of packaging materials to ensure no interaction with the herbal components and retention of efficacy.

5. Commercial and Practical Applications

Future work can also explore the market potential and practical applications:

Development of compact, travel-friendly spray bottles for daily use.

Incorporation into personal care and wellness products, such as spa or pedicure treatments.

Scale-up studies for pilot production, maintaining efficacy and quality in bulk manufacturing conditions.

6. Novelty Expansion

Further research could also expand the novelty of the product:

Combining the current formulation with biofilm-disrupting herbal agents for resistant foot pathogens.

Creating season-specific or targeted formulations, e.g., for diabetic foot care or athletes prone to sweat-related infections.

Exploring synergistic combinations with natural moisturizers or essential oils to provide multifunctional benefits.

Conclusion of Future Work:

The herbal foot spray developed in this study shows significant potential as a safe, effective, and natural foot care product. However, future research focusing on clinical evaluation, formulation optimization, advanced analytical studies, long-term stability, and commercialization strategies will not only validate and enhance its therapeutic efficacy but also establish it as a novel and competitive product in the herbal personal care market.

REFERENCES

[1]. Kirtikar KR, Basu BD. *Indian Medicinal Plants*. Vol. I–IV. Dehradun: International Book Distributors; 2005.
[2]. Kokate CK, Purohit AP, Gokhale SB. *Pharmacognosy*. 56th ed. Pune: Nirali Prakashan; 2022.
[3]. Trease GE, Evans WC. *Pharmacognosy*. 16th ed. London: Elsevier; 2009.
[4]. WHO. *Quality Control Methods for Herbal Materials*. Geneva: World Health Organization; 2011.
[5]. Rang HP, Dale MM, Ritter JM, Flower RJ. *Rang and Dale's Pharmacology*. 8th ed. Elsevier; 2016.
[6]. Harborne JB. *Phytochemical Methods: A Guide to Modern Techniques of Plant Analysis*. 3rd ed. Chapman & Hall; 1998.
[7]. Cowan MM. Plant products as antimicrobial agents. *Clin Microbiol Rev*. 1999;12(4):564–582.
[8]. Pandey G, Madhuri S. Medicinal plants: better remedy for neoteric diseases. *Int J Pharm Sci Res*. 2010;1(2):1–9.
[9]. Biswas K, Chattopadhyay I, Banerjee RK, Bandyopadhyay U. Biological activities of neem. *Curr Sci*. 2002;82(11):1336–1345.
[10]. Subapriya R, Nagini S. Medicinal properties of neem leaves. *Curr Med Chem*. 2005;12(6):1–9.
[11]. Gupta AK, Tandon N. *Reviews on Indian Medicinal Plants*. Vol. 5. New Delhi: ICMR; 2004.
[12]. Surjushe A, Vasani R, Saple DG. Aloe vera: a short review. *Indian J Dermatol*. 2008;53(4):163–166.
[13]. Chithra P, Sajithlal GB, Chandrakasan G. Influence of Aloe vera on wound healing. *Indian J Exp Biol*. 1998;36:896–901.
[14]. Reynolds T, Dweck AC. Aloe vera leaf gel: a review update. *J Ethnopharmacol*. 1999;68:3–37.
[15]. Prakash P, Gupta N. Therapeutic uses of Ocimum sanctum (Tulsi). *Indian J Physiol Pharmacol*. 2005;49(2):125–131.
[16]. Pattanayak P, Behera P, Das D, Panda SK. Ocimum sanctum: a review. *Pharmacogn Rev*. 2010;4(7):95–105.

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[17]. Singh S, Taneja M, Majumdar DK. Biological activities of Ocimum sanctum. *Indian J Exp Biol*. 2007;45:403–412.
[18]. Burt S. Essential oils: their antibacterial properties. *Int J Food Microbiol*. 2004;94:223–253.
[19]. Hammer KA, Carson CF, Riley TV. Antimicrobial activity of essential oils. *J Appl Microbiol*. 1999;86:985–990.
[20]. Carson CF, Hammer KA, Riley TV. Tea tree oil antimicrobial activity. *Clin Microbiol Rev*. 2006;19(1):50–62.
[21]. Lawless J. *The Encyclopedia of Essential Oils*. London: Harper Collins; 2002.
[22]. Kumar S, Pandey AK. Chemistry and biological activities of flavonoids. *Sci World J*. 2013;2013:1–16.
[23]. Balick MJ, Cox PA. *Plants, People and Culture*. New York: Scientific American Library; 1996.
[24]. Mukherjee PK. *Quality Control of Herbal Drugs*. 2nd ed. New Delhi: Business Horizons; 2007.
[25]. Indian Pharmacopoeia Commission. *Indian Pharmacopoeia*. Ghaziabad; 2022.
[26]. British Pharmacopoeia Commission. *British Pharmacopoeia*. London; 2021.
[27]. Ansel HC, Allen LV, Popovich NG. *Pharmaceutical Calculations*. 14th ed. Wolters Kluwer; 2019.
[28]. Allen LV. *Pharmaceutical Compounding*. 2nd ed. Washington DC: APhA; 2012.
[29]. Lachman L, Lieberman HA, Kanig JL. *The Theory and Practice of Industrial Pharmacy*. 3rd ed. Mumbai: Varghese; 2009.
[30]. Remington JP. *Remington: The Science and Practice of Pharmacy*. 22nd ed. Pharmaceutical Press; 2013.
[31]. ICH Q1A(R2). Stability Testing of New Drug Substances and Products. ICH Guidelines; 2003.
[32]. ICH Q2(R1). Validation of Analytical Procedures. ICH Guidelines; 2005.
[33]. Clinical and Laboratory Standards Institute (CLSI). Performance Standards for Antimicrobial Susceptibility Testing; 2020.
[34]. Tortora GJ, Funke BR, Case CL. *Microbiology: An Introduction*. 12th ed. Pearson; 2018.
[35]. Pelczar MJ, Chan ECS, Krieg NR. *Microbiology*. 5th ed. McGraw-Hill; 1993.
[36]. Jawetz E, Melnick JL, Adelberg EA. *Medical Microbiology*. 26th ed. McGraw-Hill; 2013.
[37]. Singleton VL, Orthofer R, Lamuela-Raventos RM. Analysis of phenols. *Methods Enzymol*. 1999;299:152–178.
[38]. Blois MS. Antioxidant determination by DPPH method. *Nature*. 1958;181:1199–1200.
[39]. Shah B, Seth AK. *Textbook of Pharmacognosy and Phytochemistry*. 2nd ed. Elsevier; 2014.
[40]. Deore SL, Khadabadi SS. Standardization of herbal formulations. *Int J Pharm Sci Res*. 2011;2(12):3131–3140.
[41]. Wagner H, Bladt S. *Plant Drug Analysis*. 2nd ed. Springer; 1996.
[42]. Sofowora A. *Medicinal Plants and Traditional Medicine in Africa*. 3rd ed. Ibadan: Spectrum Books; 2008.
[43]. Bisset NG. *Herbal Drugs and Phytopharmaceuticals*. Stuttgart: Medpharm; 1994.
[44]. Kumar V, Abbas AK, Aster JC. *Robbins Basic Pathology*. 10th ed. Elsevier; 2018.
[45]. Lippincott Williams & Wilkins. *Lippincott Illustrated Reviews: Pharmacology*. 7th ed.; 2019.
[46]. Gennaro AR. *Remington's Pharmaceutical Sciences*. 20th ed. Philadelphia; 2000.
[47]. Evans WC. *Trease and Evans Pharmacognosy*. 15th ed. Saunders Elsevier; 2008.
[48]. Kokate CK. *Practical Pharmacognosy*. 4th ed. Pune: Vallabh Prakashan; 2010.