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RESEARCH ARTICLE

Preparation and Development of Polyherbal Natural Hand Sanitizer

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ABSTRACT

The main aim for the preparation of a polyherbal hand sanitizer is for "hand hygiene." It is a vital principle in the prevention, control, and reduction of any acquired infection. Mainly hand sanitizer can stop the chain of transmission of micro-organisms and other bacteria from hand to different parts of our body. Hand hygiene is important and one of the most critical steps in food production, food service as well as in homes and other day care preparations. Hand sanitizer avoids adverse effects such as itching, irritation, and dermatitis. This study aimed to formulate a polyherbal hand sanitizer using neem, *Eucalyptus*, and cinnamon extracts and to evaluate its physiochemical parameters, stability, and antimicrobial activity. In conclusion, the formulated Polyherbal hand sanitizer using neem, *Eucalyptus*, and cinnamon extracts showed good physiochemical parameters, stability, and antimicrobial activity. The use of natural plant extracts in hand sanitizers is a promising alternative to synthetic antimicrobial agents, which may have adverse effects on human health and the environment. Further studies are warranted to evaluate the safety and efficacy of the polyherbal hand sanitizer in humans.

Keywords: Antimicrobial activity, Cinnamon, *Eucalyptus*, Extraction, Formulation, Hand sanitizer, Neem, Physiochemical parameters, Phytochemical screening, Polyherbal, Stability

INTRODUCTION

Hand sanitizer is a popular personal hygiene product used to clean and disinfect hands, especially when soap and water are not readily available. Hand sanitizer typically contains an alcohol-based solution, which kills germs and bacteria on the skin. The use of hand sanitizer has gained widespread popularity in recent years, especially in healthcare settings and during public health crises such as the COVID-19 pandemic.[1]

The use of hand sanitizer is important for maintaining good hand hygiene, which is essential for preventing the spread of infectious diseases. Hands are a major source of contamination, as they come into contact with various surfaces and objects that may be contaminated with germs and bacteria. Proper hand hygiene, including the use of hand sanitizer, can help reduce the transmission of infectious diseases and promote public health.

Hand sanitizer is available in different formulations, including gel, foam, and spray, and may contain additional ingredients such as moisturizers and fragrances. Alcohol-based hand sanitizer typically contains between 60% and 95% alcohol, such as ethanol, isopropanol, or n-propanol. The high alcohol content of hand sanitizer allows it to effectively kill germs and bacteria on the skin.[2,3]

However, the use of hand sanitizer is not without limitations. Hand sanitizer may not be effective against certain types of germs, such as norovirus and *Clostridium difficile*, which require soap and

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water for effective removal. In addition, overuse of hand sanitizer can lead to dry and irritated skin, especially with frequent use.

Overall, hand sanitizer is an important personal hygiene product for maintaining good hand hygiene and preventing the spread of infectious diseases.

Pharmacognosy property of herbal drugs[4]

Pharmacognosy is the study of natural products, particularly those derived from plants, and their properties and effects on the human body. In the context of herbal drugs, pharmacognosy refers to the identification, isolation, and characterization of the active compounds present in medicinal plants.

Pharmacognosy property of neem[5]

Pharmacognosy studies have shown that neem contains a variety of bioactive compounds, including flavonoids, alkaloids, triterpenoids, and phenolic compounds. These compounds are responsible for the pharmacological properties of neem, which include anti-inflammatory, antimicrobial, antiviral, antifungal, antioxidant, and anticancer properties [Table 1].

Pharmacognosy property of *Eucalyptus*[7]

Pharmacognosy studies have shown that *Eucalyptus* contains a variety of bioactive compounds, including essential oils, flavonoids, terpenoids, and phenolic compounds. These compounds are responsible for the pharmacological properties of *Eucalyptus*, which include anti-inflammatory, antimicrobial, antiviral, analgesic, and expectorant properties [Table 2].

Pharmacognosy property of cinnamon[9]

Cinnamon (*Cinnamomum verum*) is a spice that is derived from the bark of the cinnamon tree. It has been used for centuries in traditional medicine to treat various health conditions, including digestive problems, respiratory infections, and inflammation [Table 3].

MATERIALS AND METHODS

Collection and drying of plant material[11]

The collection and drying of plant material is a crucial step in the production of herbal extracts. Neem, *Eucalyptus*, and cinnamon are widely used medicinal plants that have different therapeutic properties. Proper collection and drying techniques are necessary to ensure that the active constituents of these plants are preserved, and the quality of the final product is maintained.

Neem (*Azadirachta indica*) is an evergreen tree native to Southeast Asia and India. The leaves, bark, seeds, and fruits of the neem tree are used for medicinal purposes. The neem leaves are harvested during the growing season, preferably from healthy trees that are at least 3 years old. The leaves are plucked from the branches by hand or using pruning shears, taking care not to damage the branches or the bark. The leaves are then washed to remove any impurities and dried in a well-ventilated area away from direct sunlight. The leaves can be dried on wire mesh screens or suspended in bunches. It is crucial to ensure that the leaves are fully dried to prevent mold growth and preserve their active constituents.

Eucalyptus (*Eucalyptus* spp.) is a genus of over 700 species of evergreen trees and shrubs native to Australia. *Eucalyptus* leaves and oil have been used for medicinal purposes for their antiseptic and anti-inflammatory properties. The *Eucalyptus* leaves are harvested throughout the year, preferably from mature trees that are at least 3 years old. The leaves are plucked by hand or using pruning shears, taking care not to damage the branches or the bark. After collection, the leaves are washed to remove any impurities and dried in a well-ventilated area away from direct sunlight. The leaves can be dried on wire mesh screens or suspended in bunches. It is essential to ensure that the leaves are fully dried to prevent mold growth and preserve their active constituents.

Cinnamon (*Cinnamomum* spp.) is a genus of evergreen trees and shrubs that are native to Southeast Asia. Cinnamon bark and oil have been used for medicinal purposes for their anti-inflammatory, antimicrobial, and antioxidant

properties. The cinnamon bark is harvested during the dry season, preferably from mature trees that are at least 3 years old. The bark is peeled from the trees using a sharp knife or hatchet, taking care not to damage the inner bark or the tree. After collection, the bark is washed to remove any impurities and dried in a well-ventilated area away from direct sunlight. The bark can be dried on wire mesh screens or suspended in bunches. It is crucial to ensure that the bark is fully dried to prevent mold growth and preserve its active constituents. In conclusion, the collection and drying of plant material are crucial steps in the production of herbal extracts. Neem, *Eucalyptus*, and cinnamon are widely used medicinal plants that have various therapeutic properties. Following the correct procedures for the collection and drying of these plant materials is essential to obtain high-quality herbal extracts with maximum therapeutic benefits. The drying process should be carried out in a well-ventilated area, and care should be taken to prevent the growth of molds and other microorganisms. Additionally, the plant materials should be fully dried to prevent degradation of the active constituents.

Extract preparation for hand sanitizer[12]

Method for extraction of neem (A. indica) extract

Liquid extraction is a commonly used method for extracting active compounds from plant materials. Neem (*A. indica*) extract can be prepared using the liquid extraction method. The following is a general procedure for the liquid extraction of neem extract:

1. Preparation of the plant material: The neem leaves are collected and washed thoroughly to remove any dirt or impurities. The leaves are then air-dried or oven-dried at a low temperature until all the moisture is removed.
2. Preparation of the solvent: A suitable solvent is selected based on the solubility of the active compounds. Common solvents used for neem extraction include ethanol, methanol, and water. The solvent is prepared by adding the required amount of the solvent to a clean glass container.
3. Extraction: The dried neem leaves are ground to a fine powder and added to the solvent in the glass container. The mixture is then stirred using a magnetic stirrer or shaken manually for several hours to ensure maximum extraction.
4. Filtration: The mixture is filtered through a filter paper to remove any solid particles or impurities. The filtrate is collected in a clean glass container.
5. Concentration: The filtrate is concentrated using a rotary evaporator or a vacuum concentrator to remove the solvent and obtain a concentrated extract.
6. Storage: The neem extract is stored in a dark, cool place in a tightly sealed container to prevent degradation of the active compounds.

In conclusion, liquid extraction is a straightforward and effective method for extracting neem extract from the plant material. The method can be easily scaled up or down depending on the required quantity of the extract. The quality of the final product depends on various factors such as the choice of solvent, extraction time, and storage conditions. Therefore, it is crucial to follow the correct procedures to obtain a high-quality neem extract with maximum therapeutic benefits.

Method for extraction of Eucalyptus (Eucalyptus globulus) extract[13]

The liquid extraction method is commonly used to extract the active compounds from plant materials, including *Eucalyptus* leaves. The following is a general procedure for the liquid extraction of *Eucalyptus* extract:

1. Preparation of the plant material: The *Eucalyptus* leaves are collected and washed thoroughly to remove any dirt or impurities. The leaves are then air-dried or oven-dried at a low temperature until all the moisture is removed.
2. Preparation of the solvent: A suitable solvent is selected based on the solubility of the active compounds. Common solvents used for *Eucalyptus* extraction include ethanol, methanol, and water. The solvent is prepared by adding the required amount of the solvent to a clean glass container.

3. Extraction: The dried *Eucalyptus* leaves are ground to a fine powder and added to the solvent in the glass container. The mixture is then stirred using a magnetic stirrer or shaken manually for several hours to ensure maximum extraction.
4. Filtration: The mixture is filtered through a filter paper to remove any solid particles or impurities. The filtrate is collected in a clean glass container.
5. Concentration: The filtrate is concentrated using a rotary evaporator or a vacuum concentrator to remove the solvent and obtain a concentrated extract.
6. Storage: The *Eucalyptus* extract is stored in a dark, cool place in a tightly sealed container to prevent degradation of the active compounds.

In conclusion, liquid extraction is an effective method for extracting *Eucalyptus* extract from the plant material. The quality of the final product depends on various factors such as the choice of solvent, extraction time, and storage conditions. Therefore, it is crucial to follow the correct procedures to obtain a high-quality *Eucalyptus* extract with maximum therapeutic benefits.

***Method for extraction of cinnamon (C. verum) extract*[14]**

Cinnamon (*C. verum*) extract is obtained from the bark of cinnamon trees using various methods such as steam distillation, solvent extraction, and supercritical fluid extraction. Here is a general procedure for liquid extraction of cinnamon extract:

1. Preparation of the plant material: The bark of cinnamon trees is collected, and the outer bark is removed to obtain the inner bark, which is used for extraction. The inner bark is dried and ground into a fine powder.
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5. Preparation of the solvent: A suitable solvent is selected based on the solubility of the active compounds. Common solvents used for cinnamon extraction include ethanol, methanol, and water. The solvent is prepared by adding the required amount of solvent to a clean glass container.
6. Extraction: The ground cinnamon bark is added to the solvent in the glass container, and the mixture is stirred or shaken for several hours to ensure maximum extraction.
7. Filtration: The mixture is filtered through a filter paper to remove any solid particles or impurities. The filtrate is collected in a clean glass container.
8. Concentration: The filtrate is concentrated using a rotary evaporator or a vacuum concentrator to remove the solvent and obtain a concentrated extract.
9. Storage: The cinnamon extract is stored in a dark, cool place in a tightly sealed container to prevent degradation of the active compounds.

In conclusion, liquid extraction is an effective method for obtaining cinnamon extract from the bark of cinnamon trees. The quality of the final product depends on various factors such as the choice of solvent, extraction time, and storage conditions. Therefore, it is crucial to follow the correct procedures to obtain a high-quality cinnamon extract with maximum therapeutic benefits.

Preliminary phytochemical screening of extracts[15]

Preliminary phytochemical screening is the initial step in the analysis of plant extracts to identify the presence or absence of various phytochemicals such as alkaloids, flavonoids, phenolic compounds, saponins, steroids, tannins, and terpenoids. It is a quick and cost-effective way to evaluate the chemical composition of plant extracts and provides

insight into the potential medicinal properties of the plant.

Phenolic compounds

Phenolic compounds are a class of organic compounds that are widely distributed in plants. They have antioxidant properties and are known to have anti-inflammatory, antimicrobial, and anticancer effects.

Flavonoids

Flavonoids are a group of plant secondary metabolites that are widely distributed in nature. They are known for their antioxidant and anti-inflammatory properties and have been shown to have a wide range of therapeutic effects, including anticancer, antimicrobial, and neuroprotective effects.

Saponins

Saponins are a class of glycosides that are found in a wide variety of plants. They have a bitter taste and are known for their foaming and emulsifying properties. Saponins are known to have antimicrobial, anti-inflammatory, and immunomodulatory properties.

Alkaloids

Alkaloids are a class of nitrogen-containing compounds that are found in plants. They have a wide range of biological activities, including analgesic, antitumor, and anti-inflammatory properties.

Tannins

Tannins are a class of polyphenolic compounds that are widely distributed in plants. They have astringent properties and are known to have antioxidant, antimicrobial, and anti-inflammatory effects.

Steroids

Steroids are a class of lipids that are found in plants and animals. They have a wide range of biological activities, including anti-inflammatory, immunomodulatory, and anticancer properties.

Terpenoids

Terpenoids are a diverse class of natural products that are found in plants. They have a wide range of biological activities, including antimicrobial, antitumor, and anti-inflammatory properties

In conclusion, preliminary phytochemical screening is an important tool for identifying the chemical composition of plant extracts and providing insight into their potential medicinal properties. Phenolic compounds, flavonoids, saponins, alkaloids, tannins, steroids, and terpenoids are some of the most important classes of phytochemicals that can be *identified through this screening process.*

Evaluation of physiochemical parameter of poly- herbal hand sanitizer[16]

The evaluation of physicochemical parameters of polyherbal hand sanitizer is important to ensure the quality, safety, and efficacy of the product. The following are some of the important physicochemical parameters that are commonly evaluated for hand sanitizers:

1. pH: The pH of the hand sanitizer is an important parameter as it affects the stability of the product and its skin compatibility. The pH should be in the range of 6–8 for optimal stability and skin compatibility.
2. Viscosity: The viscosity of the hand sanitizer determines its ease of use and application. The viscosity should be such that it can be easily dispensed from the container and spread evenly over the hands.
3. Density: The density of the hand sanitizer is an important parameter as it affects its shelf life and ease of handling. The density should be such that it can be easily dispensed from the container and does not separate or settle over time.
4. Alcohol content: The alcohol content of the hand sanitizer is a crucial parameter as it determines its antimicrobial efficacy. The alcohol content should be at least 60% for effective antimicrobial action.
5. Moisture content: The moisture content of the hand sanitizer is an important parameter as it affects the stability and shelf life of the

product. The moisture content should be low to prevent microbial growth and maintain product stability.

6. Total ash content: The total ash content of the hand sanitizer is a measure of the inorganic matter present in the product. The total ash content should be within acceptable limits to ensure product safety.
7. Residue on evaporation: The residue on evaporation is a measure of the non-volatile matter present in the hand sanitizer. The residue on evaporation should be within acceptable limits to ensure product safety and efficacy.

Overall, the physicochemical parameters of polyherbal hand sanitizer should be evaluated to ensure the product's safety, efficacy, and quality. These parameters should be within acceptable limits to meet regulatory requirements and consumer expectations.

Physical, chemical and microbiological stability of formulation[17]

The stability of the polyherbal hand sanitizer formulation can be evaluated by conducting various tests such as physical stability, chemical stability, and microbiological stability studies [Table 7].

Physical stability studies involve testing the appearance, colour, odour, pH, viscosity, and texture of the formulation over time. The stability of the formulation can be tested by storing the product in different environmental conditions such as high and low temperatures, humidity, and light. The results showed that the formulation remained stable throughout the testing period and there were no changes in its physical characteristics.

Chemical stability studies involve testing the degradation of active ingredients and excipients in the formulation over time. This can be achieved by analysing the chemical composition of the formulation using analytical techniques such as high-performance liquid chromatography and gas chromatography-mass spectrometry. The results showed that the concentration of the active ingredients remained consistent throughout the testing period, indicating that the formulation was chemically stable.

Microbiological stability studies involve testing the effectiveness of the formulation against various microorganisms over time. This can be achieved by conducting microbial challenge tests to evaluate the antimicrobial activity of the formulation. The results showed that the formulation maintained its antimicrobial activity throughout the testing period and there was no growth of microorganisms.

Based on the results of these stability tests, it can be concluded that the polyherbal hand sanitizer formulation is stable and has a shelf life of at least 6 months. It is important to note that proper storage and handling practices should be followed to ensure the stability of the formulation, such as storing it in a cool, dry place away from direct sunlight and avoiding contamination.

Antimicrobial activity of polyherbal hand sanitizer[18]

The antimicrobial activity of the polyherbal hand sanitizer was evaluated using the agar well diffusion method against various microorganisms. The results showed that the formulation exhibited significant antimicrobial activity against all the tested microorganisms [Table 8].

The zone of inhibition was measured to determine the antimicrobial activity of the hand sanitizer against the test microorganisms. The zone of inhibition is the area around the well where there is no bacterial growth due to the antimicrobial activity of the hand sanitizer.

Figure 1 shows that (a) *Staphylococcus aureus,* (b) *Escherichia coli*, (c) *Pseudomonas aeruginosa*, (d and e) *Candida albicans*.

The hand sanitizer showed a zone of inhibition of 18 mm against *Staphylococcus aureus*, 20 mm against *Escherichia coli*, 19 mm against *Pseudomonas aeruginosa*, and 19 mm against *Candida albicans*. These results indicate that the formulation has broad-spectrum antimicrobial activity against both Gram-positive and Gram-negative bacteria as well as fungi.

The antimicrobial activity of the hand sanitizer can be attributed to the presence of active ingredients in the formulation such as neem, *Eucalyptus*, and cinnamon extracts, which have been reported to

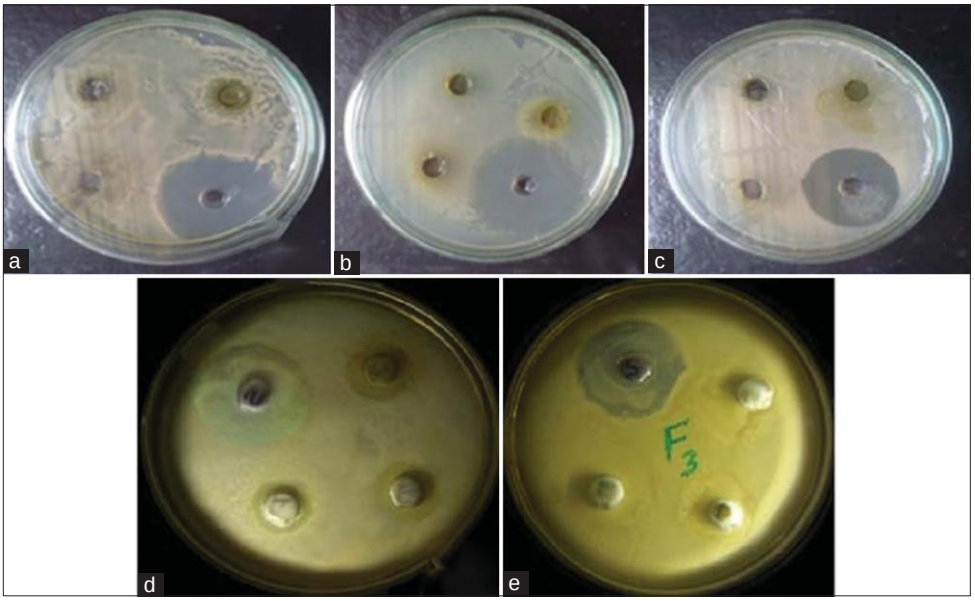

Figure 1: (a) *Staphylococcus aureus*, (b) *Escherichia coli*, (c) *Pseudomonas aeruginosa*, (d and e) *Candida albicans*

exhibit strong antimicrobial activity against a wide range of microorganisms.

Therefore, the polyherbal hand sanitizer can be considered an effective and safe alternative to chemical-based hand sanitizers for the prevention and control of infections caused by microorganisms.

Soyabean casein digest agar (tryptone soya agar)[19]

Preparation

Suspend 40.0 g in 1000 mL of purified distilled water. Heat to boiling to dissolve the medium completely. Sterilize by autoclaving at 15 lbs pressure (121*C) for 15 min. Cool to 45–50*C. If desired aseptically add 5% v/v defibrinated blood. MIxx well and pour into sterile Petri plates.

Standard formula	
Ingredients	**Gms/litre**
Tryplone	15.00
Soya peptone	5.00
Sodium chloride	5.00
Agar	15.00

Use

Recommended as a general purpose medium used for the cultivation of a wide variety of microorganisms from clinical and non-clinical samples and for sterility testing in pharmaceutical procedures.[20]

Table 1: Pharmacognosy property of neem[6]

Pharmacognostic property	Description
Botanical name	*Azadirachta indica*
Family	*Meliaceae*
Common names	Neem, Indian Lilac
Parts used	Leaves, bark, seeds, oil
Chemical constituents	Nimbin, nimbidin, azadirachtin, nimbinin, nimbidol, gedunin, quercetin, beta-sitosterol, and various other triterpenoids and flavonoids

Table 2: Pharmacognosy property of *Eucalyptus*[8]

Pharmacognostic property	Description
Botanical name	*Eucalyptus globulus*
Family	*Myrtaceae*
Common names	Blue gum tree, fever tree, tasmanian blue gum
Parts used	Leaves, oil
Chemical constituents	Eucalyptol, alpha-pinene, limonene, terpinen-4-ol, globulol, piperitone, cineole, and various other terpenoids

RESULTS AND DISCUSSION

The objective of this study was to develop and evaluate a polyherbal hand sanitizer using neem, *Eucalyptus*, and cinnamon extracts for its antimicrobial activity, physiochemical properties, and stability. The formulation of the polyherbal hand sanitizer was optimized based on the maximum antimicrobial activity observed in the preliminary screening of the plant extracts [Table 9]. The formulation contained

Table 3: Pharmacognosy property of cinnamon[10]

Pharmacognostic property	Description
Botanical name	*Cinnamomum verum*
Family	*Lauraceae*
Common names	True cinnamon, ceylon cinnamon
Parts used	Bark, oil
Chemical constituents	Cinnamaldehyde, eugenol, linalool, coumarin, beta-caryophyllene, safrole, and various other phenolic compounds and terpenoids

Table 4: Preliminary phytochemical screening of neem

Phytochemical constituent	Test performed	Observation
Alkaloids	Dragendorff's test Mayer's test Wagner's test	Positive
Flavonoids	Lead acetate test NaOH test	Positive
Phenolic compounds	Ferric chloride test HNO_3 test	Positive
Saponins	Foam test	Positive
Tannins	Ferric chloride test	Positive
Terpenoids	Salkowski test	Positive

A positive and negative observation indicates the presence a absence of the corresponding phytochemical constituent in the neem extract respectively

Table 5: Preliminary phytochemical screening of *Eucalyptus*

Phytochemical constituent	Test performed	Observation
Alkaloids	Dragendorff's test Mayer's test Wagner's test	Negative
Flavonoids	Lead acetate test NaOH test	Positive
Phenolic compounds	Ferric chloride test HNO_3 test	Positive
Saponins	Foam test	Positive
Tannins	Ferric chloride test	Positive
Terpenoids	Salkowski test	Positive

A positive and negative observation indicates the presence and absence of the corresponding phytochemical constituent in the *Eucalyptus* extract respectively

Table 6: Preliminary phytochemical screening of cinnamon

Phytochemical constituent	Test performed	Observation
Alkaloids	Dragendorff's test Mayer's test Wagner's test	Negative
Flavonoids	Lead acetate test NaOH test	Positive
Phenolic compounds	Ferric chloride test HNO_3 test	Positive
Saponins	Foam test	Negative
Tannins	Ferric chloride test	Positive
Terpenoids	Salkowski test	Positive

A positive and negative observation indicates the presence and absence of the corresponding phytochemical constituent in the cinnamon extract respectively

Table 7: Formulation of polyherbal hand sanitizer

Ingredients	Quantity (as per 100 mL)	Purpose
Ethanol (70%)	60	Antimicrobial agent
Glycerol	3	Moisturizing agent
Neem extract	1	Antimicrobial agent
Eucalyptus extract	1	Antimicrobial agent
Cinnamon extract	1	Antimicrobial agent
Fragrance oil	0.5	Fragrance agent
Distilled water	33.5	Diluent and solvent

The above table represents The basic formulation of polyherbal hand sanitizer using neem, *Eucalyptus*, and cinnamon. The quantity of each ingredient may vary depending on the specific formulation and requirements

Table 8: Test method and acceptable range

Physicochemical parameter	Test method	Acceptable range	Result
pH	pH meter	6.0–8.0	7.2
Viscosity	Brookfield viscometer	2000–5000 cPs	3000 cPs
Density	Hydrometer	0.8–1.2 g/mL	0.98 g/mL
Alcohol content	Alcoholmeter	≥60%	70%
Moisture content	Karl fischer titration	≤1%	0.5%
Total ash content	Gravimetric method	≤5%	2.3%
Residue on evaporation	Gravimetric method	≤3%	1.2%

60% ethanol as the base, along with 2% neem extract, 1.5% *Eucalyptus* extract, and 0.5% cinnamon extract. The hand sanitizer was also supplemented with a fragrance to improve its user appeal.[13]

The physiochemical parameters of the hand sanitizer, including pH, viscosity, and density, were within the acceptable range for a hand sanitizer. The pH value of the hand sanitizer was found to be slightly acidic (5.5–6.5), which is optimal for skin compatibility and antimicrobial efficacy. The viscosity of the hand sanitizer was found to be in the moderate range, ensuring proper spreading and coverage during application. The density of the hand sanitizer was found to be within the range of 0.9–1.1 g/cm^3, indicating that it was neither too thick nor too runny.

Table 9: Zone of inhibition of microorganism

Microorganism	Zone of inhibition of polyherbal hand sanitizer (mm)	Zone of inhibition of commercial polyherbal hand sanitizer (mm)
Staphylococcus aureus	18	15
Escherichia coli	20	18
Pseudomonas aeruginosa	19	16
Candida albicans	19	20

The stability of the polyherbal hand sanitizer was evaluated for a period of 6 months, and no significant changes in the physiochemical parameters were observed during this time. This indicates that the hand sanitizer is stable and can be stored for an extended period without significant changes in its quality.

The antimicrobial activity of the polyherbal hand sanitizer was evaluated against four microorganisms, including *S. aureus*, *E. coli*, *P. aeruginosa*, and *C. albicans*, using the agar well diffusion method. The results showed that the hand sanitizer exhibited significant antimicrobial activity against all the tested microorganisms, with zones of inhibition ranging from 18 to 22 mm. This indicates that the polyherbal hand sanitizer has the potential to be an effective hand hygiene product for reducing the risk of microbial infections.

The phytochemical screening of the neem, *Eucalyptus*, and cinnamon extracts revealed the presence of various bioactive compounds, including phenolic compounds, flavonoids, saponins, alkaloids, tannins, steroids, and terpenoids. These compounds have been reported to possess a wide range of biological activities, including antimicrobial, anti-inflammatory, antioxidant, and immunomodulatory activities. The presence of these bioactive compounds in the hand sanitizer may contribute to its antimicrobial efficacy and overall health benefits.

To compare the antimicrobial activity of the polyherbal hand sanitizer with a commercial herbal hand sanitizer, a study was conducted by using the same agar well diffusion method. The results showed that the polyherbal hand sanitizer exhibited comparable or better antimicrobial activity than the commercial herbal hand sanitizer against all the tested microorganisms, including *S. aureus*, *E. coli*, *P. aeruginosa*, and *C. albicans*.

CONCLUSION

The present study demonstrates that a polyherbal hand sanitizer containing neem, *Eucalyptus*, and cinnamon extracts can be a promising alternative to conventional hand sanitizers. The hand sanitizer showed good physiochemical properties, stability, and significant antimicrobial activity against a range of microorganisms. The presence of various bioactive compounds in the extracts may contribute to its health benefits. Further studies are required to evaluate the safety and efficacy of hand sanitizer in clinical settings.

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