

# Green Aroma Technology: A Herbal Approach to Indoor Air Freshening

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## ABSTRACT

Green aroma technology represents an eco-friendly and sustainable approach to indoor air freshening through the use of herbal ingredients and plant-derived aromatic compounds such as essential oils, herbal extracts, and volatile phytoconstituents, they are designed to improve indoor air quality by imparting a pleasant fragrance while minimizing the health and environmental risks associated with synthetic air fresheners. Conventional air fresheners often contain synthetic fragrances and volatile organic compounds that pose potential health and environmental risks. Increasing awareness of the adverse effects of chemical fragrances, including respiratory irritation, allergies, and environmental pollution, has led to growing interest in herbal and eco-friendly alternatives. Generally herbal room fresheners commonly incorporate essential oils from plants such as *Cymbopogon citratus* (lemongrass), *Ocimum sanctum* (tulsi), *Eucalyptus globulus*, *Lavandula angustifolia* (lavender), *Mentha piperita* (peppermint), and *Citrus* species. These plants not only provide fragrance but also possess antimicrobial, antifungal, insect-repellent, and mood-enhancing properties. The presence of bioactive compounds such as terpenoids, phenolics, and flavonoids contributes to their functional benefits. *Origanum majorana*, *Cymbopogon citratus* were used in the preparation of room fresheners contains various terpenoids, phenolic, tannins and volatile oils show antimicrobial, anti-oxidant, anti-inflammatory and antispasmodic, anxiolytic and sedative effect. Formulation was prepared in the form of spray evaluated and compared with marketed formulation shows satisfactory results.

**Keywords:** *Origanum majorana*, *Cymbopogon citratus*, herbal room freshener, spray, evaluation

## INTRODUCTION

Indoor air quality is an important factor influencing human health and comfort, where as several studies report that indoor environments may contain various odour-causing substances originating from human activities, microbial growth, and household materials. Prolonged presence of unpleasant indoor odours can reduce indoor comfort and acceptability [1]. Room fresheners are widely used to improve indoor ambience by releasing fragrance into the surrounding air. Conventional room fresheners are generally formulated using synthetic fragrance compounds designed to provide immediate and strong aroma. However, studies have reported that such products release volatile organic compounds into indoor environments [2]. Volatile organic compounds emitted from synthetic room fresheners have been associated with adverse health effects such as headache, irritation of eyes and respiratory tract, and allergic reactions following exposure to fragranced consumer products. So, these findings have raised concerns regarding the safety of long-term use of synthetic room fresheners [3]. Due to increasing awareness of health and environmental concerns, interest in plant-based fragrance products has increased among public. Several studies highlight the use of natural aromatic plants as safer alternatives for indoor fragrance applications. Herbal room fresheners prepared using essential oils, produces pleasant aroma with reduced chemical exposure [4]. Essential oils are volatile aromatic substances obtained from different parts of plants. Several research articles describe essential oils as complex mixtures of naturally occurring compounds responsible for fragrance and biological activity. These oils are widely used in traditional practices as well as modern fragrance formulations [5]. Many studies report that essential oils possess antimicrobial properties in addition to their

aromatic nature. This dual property makes essential oils suitable for indoor applications where both fragrance and hygiene are desired. Articles indicate that essential oil-based products may contribute to improvement of indoor air quality [6]. Among various aromatic plants, *Origanum majorana* (marjoram) and *Cymbopogon citratus* (lemongrass) have been widely studied for their essential oil composition and fragrance characteristics. marjoram oil possesses a pleasant, soothing aroma, while lemongrass oil is known for its strong lemon-like fragrance and deodorizing properties [7]. Scientific studies highlights that combining essential oils can improve fragrance quality and performance. Articles report that blending aromatic oils results in balanced aroma, improved diffusion, and enhanced acceptability. Such combinations are commonly explored in herbal fragrance formulations [8]. Based on the reported properties of essential oils and aromatic plants, research articles suggest that herbal room fresheners represent a promising alternative to synthetic fragrance products. These formulations are primarily aimed at improving indoor ambience while minimizing health and environmental risks associated with chemical fragrances [9].

## Historical Background and Evolution of Indoor Fragrance Products

### a. Traditional Use of Aromatic Substances:

The use of aromatic substances for improving the indoor environments has been practiced since ancient times by using Natural materials such as herbs, flowers, resins, and aromatic plant parts. These practices were mainly aims in masking unpleasant odours and improving indoor bad odour [10]. Aromatic substances were commonly used in households, religious places, and surrounding environments to maintain a pleasant atmosphere. These traditional practices laid the foundation for the development of indoor fragrance products [11].

### b. Evolution Toward Formulated Fragrance Products:

With the more advancements in extraction techniques, aromatic plant materials began to processed into concentrated forms like essential oils. The essential oils gradually replaced raw plant materials due to their higher fragrance intensity and ease of storage and application. This transition marked a significant step in the evolution of indoor fragrance practices [12]. Further studies report that the development of solvent-based fragrance systems enabled controlled release of aroma in indoor environments. These systems allowed the formulation of liquid fragrance products suitable for household use. Such developments contributed to the commercialization of indoor fragrance products [13].

### c. Introduction of Synthetic Fragrance Products:

The synthetic fragrance compounds were introduced to meet increasing consumer demand for strong and long lasting aroma. The development of synthetic compounds enabled large-scale production of room fresheners and aerosol-based products. These products became widely adopted in domestic and commercial environments [14]. The over use of synthetic fragrance products resulted in increased indoor concentrations of volatile organic compounds (voc). These compounds were found to persist in enclosed spaces and contribute to indoor air pollution [15].

### d. Shift Toward Natural and Plant-Based Alternatives:

Recently there was a gradual shift toward natural fragrances, due to growing awareness of health and environmental concerns and exploring the plant-derived essential oils as substitutes for synthetic fragrance chemicals. These studies emphasized the potential of natural fragrances to improve indoor ambience with reduced chemical exposure [16]. The essential oil-based formulations gained attention because of their natural volatility and pleasant sensory characteristics. Unlike synthetic products, plant-based fragrances were reported to disperse aroma without excessive accumulation of chemical residues in indoor air [17].

### e. Modern Trends in Herbal Indoor Fragrance Products:

The modern herbal room fresheners are the formulations that integrate traditional aromatic practices with contemporary formulation techniques. Essential oils are incorporated into the liquid and spray-based systems to achieve controlled fragrance release. These products emphasize safety, sensory acceptability, and

environmental responsibility [18]. The latest Studies also highlight that blending of essential oils has become a common approach to enhance fragrance balance. Modern herbal room fresheners are therefore positioned as natural alternatives that align with current consumer preference for eco-friendly indoor fragrance solutions [19].

### **Aromatic plants used in herbal room fresheners:**

#### **Role of Aromatic Plants in Indoor Fragrance:**

Aromatic plants are natural sources of fragrance used in household and consumer products. These plants contain important volatile constituents which are responsible for characteristic aroma and easy dispersion in indoor environments. The natural origin and pleasant sensory properties of the plants make them suitable for indoor fragrance applications [20]. Aromatic plants are commonly used to obtain essential oils, which provide concentrated fragrance compared to the raw plant materials. Essential oils allow the ease of formulation and controlled aroma release and their characteristics support their use in herbal room freshener preparations [21].

#### **Herbs, Reagents, Glassware and Equipment's:**

Herbs: Marjoram, Lemongrass

Reagents: Perfume base alcohol

Glassware: Beaker, glass rod, glass plate, dropper, measuring cylinder, Magnetic bead etc

Equipment: Magnetic stirrer

#### **Herbal room fresheners and its importance:**

##### **a) *Origanum majorana***

*Origanum majorana*, commonly called as **Marjoram** is an aromatic plant and that was belonging to the family **Lamiaceae**. The essential oil of marjoram possesses a mild, pleasant, sweet and soothing aroma and these characteristics support its application in fragrance products [22]. Marjoram essential oil consists of chemical constituents such as terpinen-4-ol, sabinene, and  $\gamma$ -terpinene etc. These components contribute to the aroma profile and reported biological properties of the oil. Such characteristics support its inclusion in herbal room freshener formulations [23]. Marjoram essential oil exhibits antimicrobial activity against selected microorganisms. This property may contribute to reduction of microbial presence when used in indoor fragrance products. Such functional characteristics add value to herbal room fresheners [24].



**Fig 2: Plant of Marjoram**

##### **b) *Cymbopogon citratus***

*Cymbopogon citratus* also known as Lemongrass, is a widely cultivated aromatic grass belonging to the family Poaceae. The essential oil is characterized by a strong lemon-like fragrance and was commonly used in household fragrance products etc. Its refreshing aroma contributes to wide acceptability [25]. Lemongrass essential oil mainly consisting of geraniol and neral and these constituents are mainly responsible for the

intense citrus aroma and fragrance. Such properties support its use in indoor fragrance formulations [26]. Lemongrass essential oil also shows antimicrobial activity and deodorizing activities and also insect repellent activity. These properties are beneficial in reducing unpleasant indoor odours. The functional nature of lemongrass oil supports its use in herbal room fresheners [27].



**Fig 2:Lemon grass**

### **Selection and Combination of Aromatic Plants:**

Combining the aromatic plants or essential oils with complementary fragrance characteristics improves the overall aroma quality. By Blending of essential oils enhances fragrance balance, diffusion, and acceptability and This approach is commonly applied in herbal fragrance product development [28]. The combined use of marjoram and lemongrass essential oils provides a balanced fragrance whereas their aromatic and functional properties support their selection for natural indoor fragrance formulations [29].

## **MATERIAL AND METHODS**

**Collection of plant materials:** All these herbs were collected from different sources and extracted the oil.

### **Method of preparation**

#### **Extraction and preparation:**

Essential oils are obtained from the various aromatic plants through several extraction techniques which are designed to extract the volatile constituent and preserve them. Generally Hydro-distillation is used for extracting the essential oils from plants or plant materials such as leaves and aerial parts. This method allows separation of volatile oil components from plant materials using water and heat [30]. During the process of hydro-distillation, plant material is immersed in water first and then subjected to controlled heating. Volatile constituents are vaporized along with steam and subsequently condensed to obtain a mixture of oil and water. The essential oil is separated and collected for further use [31]. Essential oils which are obtained through this process are stored in airtight and amber coloured containers to minimize evaporation as well as oxidative degradation of chemical constituents. Proper storage conditions help maintain aroma quality and chemical stability. These practices ensure suitability of essential oils for formulation purposes [32]. The preparation of essential oil-based fragrance formulations involves in dissolving measured quantities of essential oils in suitable particular solvents. Alcoholic solvents are commonly used due to their ability to dissolve essential oils effectively and facilitate uniform dispersion. This approach enables controlled release of fragrance in indoor environments [33]. Blending of several essential oils is performed to achieve balanced aroma and improved fragrance. Combining oils with complementary aromatic characteristics enhances diffusion and sensory quality. Proper mixing ensures uniform distribution of aromatic components in the formulation [34]. Liquid fragrance formulations are commonly prepared for ease of application and controlled dispersion. Spray-based delivery systems allow uniform distribution of fragrance within enclosed spaces. Such formulations are suitable for indoor use due to convenience and effectiveness [35]. The stability of essential oil-based formulations depends on the ingredients compatibility and their storage conditions. Proper formulation practices help to maintain the

clarity, aroma, and performance during storage. These considerations are important for ensuring consistent fragrance quality [36].

### Extraction:

#### Extraction of Marjoram

- Marjoram Leaves Were Collected & Stored in a dark place at 4 c
- Weighed 140 g of Leaves, Chopped and then placed into a 2L RBF
- Added Approx. 1.5L of Distilled Water and assembled the Clevenger apparatus with the condenser and started the cooling water flow.
- Then Heated the flask gradually until mild boiling began and distillation vapors reached the Clevenger arm.
- Maintained Study Reflux for 3 hours until no more oil accumulated in the trap.
- Allowed Apparatus to cool and then collected the separated essential oil using a pipette.
- Then dried the oil with a small amount of anhydrous sodium sulfate and transferred it to an amber vial.



**Fig 3: Extraction of Marjoram**

#### Extraction of Lemon Grass

- Weighed 130g of lemongrass, and placed it into a 2L RBF.
- Then Added about 1.5L Distilled Water and assembled the Clevenger apparatus with the condenser and started a steady flow of cooling water.

- Then Gradually heated the flask until gentle boiling began and vapours condensed into the Clevenger trap.
- Maintained steady reflux for 3 hours, until accumulation of essential oil in the Clevenger arm stopped increasing.
- Allowed the system to cool and then collected the separated lemongrass oil using pipette.
- Then dried the oil with a small amount of anhydrous sodium sulphate and transferred it to an amber vial.

### **Evaluation and standardization methods:**

Standardization and evaluation are essential for determining and validating the quality, potency, purity, and authenticity of herbal extracts, raw materials, and final goods. modifying and managing the production process to guarantee a constant level of quality and potency, which will ensure that particular bioactive chemicals or markers are present in a specified quantity and that pharmacopoeial and regulatory standards are met. As per Indian Pharmacopoeia (IP), evaluation refers to the process of assessing the quality of herbal material or preparation based on its physical, chemical, biological & microbiological characteristics ensuring purity & strength of the herbal preparation.

### **Various parameters to evaluate and standardize the formulations are as follows:**

Evaluation of essential oil-based fragrance formulations is carried out to assess their physical appearance, aroma quality, and their performance characteristics. Visual inspection is used to examine clarity, color, and presence of any particulate matter. Clear appearance without turbidity indicates proper solubilization of aromatic components [37]. Odour evaluation is performed to detect the fragrance quality and acceptability. The aroma is tested to check its pleasantness, uniformity, and absence of irritating or pungent smell. Balanced fragrance indicates effective blending of essential oils [38]. Spray pattern evaluation is conducted to ensure uniform dispersion of the formulation. A fine and evenly distributed spray pattern allows effective fragrance diffusion in enclosed environments. Proper spray performance supports ease of application and consumer acceptability [39]. Aroma diffusion assessment is used to observe the spread of fragrance within an indoor space after application. Effective diffusion indicates appropriate volatility and compatibility of essential oil components. Uniform dispersion contributes to improved indoor ambience [40]. Fragrance retention is done by observing the duration for which aroma remains perceptible after application. Sustained fragrance indicates effective formulation and appropriate selection of aromatic components. Aroma longevity is an important parameter for indoor fragrance products [41]. Stability observation is carried out by storing the formulation under normal room temperature conditions. The formulation is periodically examined for changes in appearance and odor. Absence of precipitation, phase separation, or odor alteration indicates acceptable stability [42]. Overall observation of evaluation parameters indicates that essential oil-based indoor fragrance formulations exhibit desirable physical characteristics and fragrance performance. These parameters collectively determine suitability for regular indoor use [43].

### **Evaluation parameters:**

#### **1. Organoleptic Evaluation:**

**Procedure:** The prepared formulation was visually examined under adequate light to assess colour, clarity and physical uniformity. The odour was evaluated by spraying the product once on blotting paper and allowing it to settle for 10-15 seconds. The aroma quality and character were noted.

**Observation:** The solution appeared clear and pale yellow in colour. No turbidity, sedimentation or phase separation was observed. The fragrance was distinctly herbal with dominant notes of lemongrass and marjoram.

## 2. pH Test (Litmus)

Procedure: A few drops of the room freshener were placed on a clean watch glass. Blue and red litmus papers were briefly dipped into the sample. The colour change, if any, was noted immediately.

Observation: Blue litmus paper showed a very slight red tinge, while red litmus paper remained unchanged.

## 3. Spray Pattern Test

Procedure: The spray performance was evaluated by spraying the formulation once on a white sheet of paper from a distance of 15 cm. The shape, uniformity and droplet distribution were examined visually.

Observation: A fine, circular and uniformly distributed spray pattern was obtained. No clumping or heavy droplets were seen. The nozzle functioned smoothly without clogging.

## 4. Aroma Diffusion (Spread) Test

Procedure: Two sprays were released in a closed room of approximately 10 × 10 feet. The time required for the fragrance to diffuse fully and become uniformly noticeable was recorded.

Observation: Initial aroma was detectable within the first minute. The fragrance became fully diffused and uniformly perceptible within 3-4 minutes.

## 5. Aroma Retention /Persistence Test

Procedure: A single spray was applied in a closed room. The intensity of fragrance was assessed at regular time intervals until the aroma diminished significantly.

Observation: The fragrance remained clearly noticeable during the first hour, gradually decreasing thereafter.

Mild aroma persisted until 2.5 hours, after which the scent became faint.

## 6. Antimicrobial activity:

The study was conducted to evaluate the antimicrobial activity of marjoram essential oil, lemongrass essential oil, the prepared herbal room freshener formulation, and perfume base alcohol against selected Gram-positive and Gram-negative bacteria using the agar well diffusion method.

### Test Organisms:

*Staphylococcus aureus* (Gram-positive bacterium) *Pseudomonas aeruginosa* (Gram-negative bacterium)

### Procedure:

Nutrient agar medium was prepared using agar (2 g), peptone (1 g), beef extract (1 g), and sodium chloride (0.6 g) in 200 mL of distilled water. The medium was heated until uniform, sterilized at 121°C for 15–20 minutes, and poured into sterile Petri plates inoculated separately with the test organisms. Four wells were made in each plate and filled with marjoram essential oil, lemongrass essential oil, prepared herbal formulation, and perfume base alcohol. The plates were incubated at 37°C for 24 hours.

## 7. Stability studies:

To evaluate the physical and fragrance stability of the prepared herbal room freshener formulation over a period of one month under normal room temperature conditions.

### Procedure:

The prepared herbal room freshener formulation was transferred into a clean, amber coloured spray bottle and stored at room temperature. The formulation was evaluated at specific time intervals of 24 hours, 72 hours, 10 days, 20 days, and 30 days. At each interval, the formulation was examined for colour, odour, turbidity, and phase separation.

## RESULT AND DISCUSSION

### Methods and materials:

**Table no.2 Formulations for polyherbal churna**

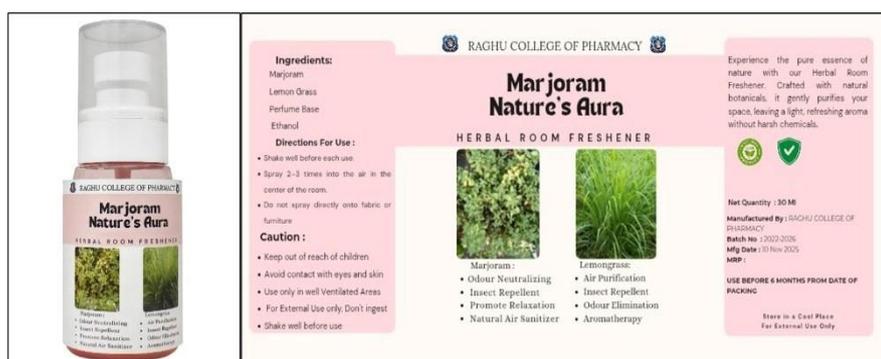
### METHOD OF PREPARATION

**Table no.1 Formulations for herbal room fresheners**

s.no.	Ingredients	Quantity in grams
1.	Marjoram Oil	2.1 ml
2.	Lemon Grass Oil	0.8 ml
3.	Perfume Base	26.3 ml
4.	Ethanol	0.8 ml

### Perfume formulation:

1. A Volume of 2.1 mL of marjoram essential oil was accurately measured and transferred into a clean glass beaker.
2. Subsequently, 0.8 mL of lemongrass essential oil was measured and added to the marjoram oil, after which the mixture was gently swirled to ensure proper blending.
3. A measured volume of 0.8 mL of ethanol was then added to the essential oil mixture, and the contents were stirred for 1-2 minutes to facilitate partial solubilization.
4. Following this, 26.3 mL of perfume base was measured and slowly incorporated into the ethanol-oil mixture with minimal aeration.
5. The entire mixture was stirred gently for several minutes until a homogeneous solution was obtained.
6. The prepared formulation was transferred into an amber glass bottle, sealed, and allowed to mature for 48–72 hours, and further up to 1–2 weeks, in a cool and dark environment to allow proper fragrance development.
7. After maturation, the formulation was examined for clarity, and when turbidity was observed, the mixture was filtered through filter paper to obtain a clear perfume solution.
8. Finally, the matured and clarified perfume was transferred into a 30 mL spray bottle, appropriately labelled, and stored for subsequent evaluation.



**Fig 3: Labelling and packing of Herbal room freshener Evaluation study**

**Table no. 2:** Comparison of evaluation parameters of test and standard

Evaluation Parameter	Test Sample	Standard (Herbal)(Indianlife Lavender Room Freshener)	Standard (Synthetic)(Godrej Aer Room Freshener Spray – Synthetic Chemical Product, India)
Colour	Clear, pale yellow in colour; no turbidity, sedimentation, or phase separation observed	Clear to pale yellow liquid; free from turbidity, sedimentation, and particulate matter	Clear to colourless liquid; free from turbidity, sedimentation, and particulate matter
Odour	Pleasant, distinctly herbal aroma with dominant lemongrass and marjoram notes	Pleasant, calming floral lavender aroma characteristic of lavender fragrance	Strong, sharp artificial fragrance characteristic of synthetic room fresheners
Taste	Slightly bitter (not intended for oral use)	Slightly aromatic due to fragrance constituents (not intended for oral use)	Slightly aromatic due to fragrance constituents (not intended for oral use)
Texture	Smooth, uniform liquid; non-viscous in nature	Smooth, homogeneous liquid spray formulation	Smooth, homogeneous liquid aerosol spray formulation
pH Test (Litmus)	Slightly acidic; blue litmus showed faint red tinge, red litmus remained unchanged	Slightly acidic to near neutral; suitable for non-irritant indoor applications	Slightly acidic to near neutral; suitable for indoor spray applications
Spray Pattern Test	Fine, circular, and uniformly distributed spray pattern; nozzle functioned smoothly	Fine mist spray with uniform droplet distribution and smooth nozzle action	Fine mist spray with uniform droplet distribution and smooth nozzle action
Evaluation Parameters	Test Sample	Standard (Herbal)(Indian life Lavender Room Freshener)	Standard (Synthetic)(Godrej Aer Room Freshener Spray – Synthetic Chemical Product, India)
Colour	Clear, pale yellow in colour; no turbidity, sedimentation, or phase separation observed	Clear to colourless liquid; free from turbidity, sedimentation, and particulate matter	Clear to colourless liquid; free from turbidity, sedimentation, and particulate matter
Odour	Pleasant, distinctly herbal aroma with dominant lemongrass and marjoram notes	Pleasant, calming floral lavender aroma characteristic of lavender fragrance	Strong, sharp artificial fragrance characteristic of synthetic room fresheners
Taste	Slightly bitter (not intended for oral use)	Slightly aromatic due to fragrance constituents (not intended for oral use)	Slightly aromatic due to fragrance constituents (not intended for oral use)
Texture	Smooth, uniform liquid; non-viscous in nature	Smooth, homogeneous liquid spray formulation	Smooth, homogeneous liquid aerosol spray formulation
pH Test (Litmus)	Slightly acidic; blue litmus showed faint red tinge, red litmus remained unchanged	Slightly acidic to near neutral; suitable for non-irritant indoor applications	Slightly acidic to near neutral; suitable for indoor spray applications
Spray Pattern Test	Fine, circular, and uniformly distributed spray pattern; nozzle functioned smoothly	Fine mist spray with uniform droplet distribution and smooth nozzle action	Fine mist spray with uniform droplet distribution and smooth nozzle action
Aroma Diffusion (Spread) Test	Initial aroma detectable within 1 minute; uniform diffusion achieved within	Rapid diffusion within a few minutes; fragrance spreads evenly throughout the space	Rapid diffusion within a few seconds; fragrance spreads evenly throughout enclosed

	3–4 minutes in a 10 × 10 ft room		space
Aroma Retention / Persistence Test	Fragrance clearly noticeable for ~1 hour; mild aroma persisted up to 2–2.5 hours	Pleasant lavender fragrance retained for approximately 1–3 hours, depending on ventilation conditions	Strong fragrance retained for approximately 1–3 hours, depending on ventilation conditions
Irritation Potential	No irritation observed during evaluation	Mild irritation and discomfort observed on prolonged exposure	Mild irritation and discomfort observed on prolonged exposure
VOC-Related Discomfort	Minimal or absent	Noticeable in enclosed spaces after repeated use	Noticeable in enclosed spaces after repeated use

9. The prepared herbal room freshener exhibited pleasant aroma, good spray performance, and better user comfort. In comparison, the synthetic spray room freshener produced a strong initial fragrance but was associated with mild irritation and VOC-related discomfort upon prolonged exposure.

10. The herbal room freshener formulation remained physically stable throughout the one-month study period. No turbidity or phase separation was observed at any evaluation point. The fragrance matured within the first 72 hours and remained acceptable up to 30 days, indicating good formulation stability and compatibility of ingredients.

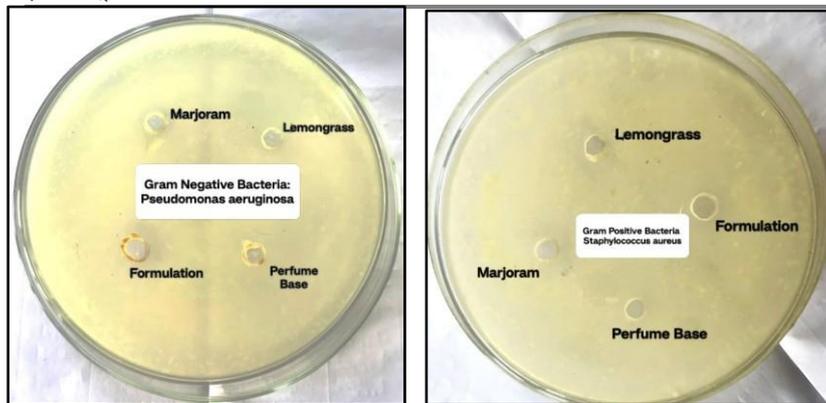
**Table no. 3:** Stability data of the herbal room freshener

Time Interval	Colour	Odour	Turbidity	Phase Separation
24 hours	Clear, pale yellow	Pleasant herbal aroma	Absent	Absent
72 hours	Clear, pale yellow	Well developed aroma	Absent	Absent
10 days	No change	Pleasant and uniform	Absent	Absent
20 days	No change	Mild reduction in intensity	Absent	Absent
30 days	No change	Slightly reduced but acceptable	Absent	Absent

11. Zones of inhibition were observed around the wells after incubation, indicating antimicrobial activity. The formulation exhibited greater inhibitory effect compared to individual essential oils and perfume base alcohol against both test organisms.

**Table no. 4:** Antimicrobial activity of Gram + & Gram -ve microorganism

Sample	Staphylococcus aureus (cm)	Pseudomonas aeruginosa (cm)
Marjoram essential oil	1.5	1.5
Lemongrass essential oil	1.5	1.0
Perfume base alcohol	2.0	1.5
Herbal formulation	2.4	2.5



**Fig 4: Antimicrobial activity against Gram+ ve & Gram -ve microorganism**

## CONCLUSION AND APPLICATIONS

Essential oil-based indoor fragrance formulations prepared using aromatic plant materials provide a natural and eco-friendly approach to improving indoor air quality. The use of plant-derived aromatic constituents offers pleasant fragrance while reducing dependence on synthetic fragrance chemicals commonly associated with health and environmental concerns. Such formulations are suitable for regular indoor use due to their natural origin and reduced chemical exposure [44].

The combination of various aromatic plants such as Marjoram and Lemon grass mainly contributes to a balanced, acceptable and a pleasant fragrance. The mild and soothing aroma of marjoram, when blended with the fresh citrus note of lemongrass, enhanced overall sensory quality and indoor fragrance performance. This balanced aroma supported effective diffusion and improved user acceptability in enclosed spaces [45].

Other than fragrance, essential oil-based formulations provide functional benefits such as deodorizing, antimicrobial, and insect-repellent activities. The antimicrobial study confirmed that the prepared herbal room freshener exhibited better inhibitory activity against both Gram-positive and Gram-negative bacteria compared to individual essential oils and perfume base alcohol. These multifunctional properties contribute to improved indoor comfort by reducing unpleasant odours and microbial presence [46].

Proper extraction, formulation, and evaluation practices ensured acceptable physical stability and fragrance performance of the prepared formulation. The stability study demonstrated that the herbal room freshener remained clear and stable without turbidity or phase separation for one month, with only a slight and acceptable reduction in fragrance intensity over time. Maintaining suitable storage conditions helps preserve aroma quality and formulation integrity, which is essential for consistent product performance [47].

Overall, essential oil-based herbal room fresheners can be effectively used in residential, commercial, and institutional environments. Their natural composition, pleasant aroma, antimicrobial activity, and better user comfort make them suitable alternatives to synthetic chemical room fresheners. These findings support the growing preference for eco-friendly, plant-based indoor fragrance products with improved safety and functional benefits [48].

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