

Formulation And Evaluation of Herbal Inhalation Pods to Relief Nasal Congestion

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Abstract

Background: Nasal congestion is a common symptom of upper respiratory tract infections, sinusitis, and seasonal allergies. Synthetic decongestants offer temporary relief but may cause adverse effects with long-term use. Herbal essential oils such as clove oil, mentha oil, camphor oil, eucalyptus oil, and thymol possess proven decongestant, antimicrobial, and soothing properties, making them promising candidates for natural inhalation therapy. **Objective:** To formulate and evaluate herbal inhalation pods using selected essential oils for effective and safe relief from nasal congestion. **Materials and Methods:** Herbal inhalation pods were prepared by impregnating a porous cotton base with a standardized blend of clove, mentha, camphor, eucalyptus oils, and thymol in optimized ratios. The formulations were assessed for physicochemical characteristics (odor intensity, weight uniformity, and oil retention), *in vitro* aroma longevity, and evaporation profile. Antimicrobial activity was tested against *Staphylococcus aureus* and *Escherichia coli*, while preliminary decongestant efficacy was evaluated through sensory relief and inhalation tests. **Results:** The optimized formulation exhibited sustained aroma release for 6–8 hours, stable physicochemical properties, and significant antimicrobial activity against tested strains. Sensory evaluation indicated rapid nasal clearance and improved breathing comfort within 5 minutes of inhalation. **Conclusion:** The developed herbal inhalation pods provide an effective, natural, and portable solution for nasal congestion relief. Their synergistic essential oil composition ensures prolonged aroma diffusion, antimicrobial protection, and quick symptomatic relief without the side effects of synthetic decongestants.

Key Words:

Herbal Inhalation Pods, Nasal Congestion, Clove Oil, Mentha Oil, Camphor, Eucalyptus Oil, Thymol

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I. INTRODUCTION

Nasal medication administration originated with topical treatments for local effects. Nasal therapy, or 'Nasya karma', is a recognized kind of treatment in the Ayurvedic system of Indian medicine, with pharmacokinetic profiles that are frequently identical to those obtained after an intravenous injection with a bioavailability approaching 100%¹. In the 1980s, nasal administration was considered a viable alternative to traditional drug delivery methods. On the other hand, absorption of hydrophilic drugs can be enhanced by absorption enhancers².

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Intranasal drug delivery appears to be a favourable method of avoiding blood levels, a quicker onset of pharmacological activity, and fewer side effects^{3,4}. The nasal route is accessible, easy, and trustworthy. Its porous endothelium membrane and highly vascularized epithelium allow for fast absorption of drugs into the systemic circulation, avoiding hepatic first pass elimination. Furthermore, intranasal drug delivery facilitates the reduction of doses, quick attainment of therapeutic invasiveness, self-administration, patient comfort, and patient compliance—all of which are obstacles in intravenous drug therapy⁵. It has been reported that hydrophilic drugs, which range from small chemicals to large macromolecules, such as hormones, vaccines, and peptide/protein therapeutics, are delivered through the nasal cavity⁶.

Nasal administration appears to be a good method of getting beyond the blood-brain barrier's (BBB), enabling direct medication delivery in the biophase of active substances in the central nervous system (CNS). Vaccine administration has also been contemplated^{7, 8}. Peptides that have been effectively delivered via the nasal route include buserelin, desmopressin, calcitonin, insulin, luteinizing hormone releasing hormone, growth hormone, and adreno-corticotrophic hormone. In addition to these, it has been demonstrated that several medications have significant systemic effects, including steroids (corticosteroids, estradiol, progesterone, testosterone, and so forth^{9, 10}, antihypertensives (nifedipine, nitroglycerine, propranolol, hydralazine, and so forth), analgesics (buprenorphine), antibiotics, and antivirals¹¹.

When given through the nasal passage. There are several methods for nasal medication delivery, including nasal spray. Studies have been conducted on nasal pumps, gels, suspensions, microemulsions, powders, and thermo reversible mucoadhesive gels¹². Pharmaceutical scientists and physicians have been paying more and more attention to the viability of nasal medication administration during the last few decades.

Nasal congestion, commonly referred to as a blocked nose, is a frequent symptom associated with upper respiratory tract infections, sinusitis, and allergic rhinitis. It occurs primarily due to inflammation and swelling of the nasal mucosa, which restricts airflow and causes discomfort. Persistent nasal blockage not only affects breathing but also disrupts sleep, reduces productivity, and impacts quality of life. Conventional treatments for nasal congestion include oral decongestants, antihistamines, and topical nasal sprays, which may cause rebound congestion, drowsiness, or mucosal irritation with prolonged use¹⁴.

Herbal essential oils have been used in traditional medicine and aromatherapy for their decongestant, anti-inflammatory, and antimicrobial properties. Oils such as clove (*Syzygium aromaticum*), mentha (*Mentha piperita*), camphor (*Cinnamomum camphora*), eucalyptus (*Eucalyptus globulus*), and thymol are especially effective. Eucalyptus and mentha oils help decongest and provide a cooling sensation, camphor soothes nasal passages, and clove oil and thymol exhibit potent antimicrobial effects. Combining these oils can produce synergistic relief from nasal congestion¹⁵.

Inhalation therapy is a non-invasive and rapid delivery method for essential oils. Herbal inhalation pods, compact and portable, can deliver therapeutic vapors efficiently. By

impregnating a porous absorbent base with essential oils, sustained aroma release can be achieved¹⁵.

Synthetic decongestants often lead to adverse effects such as rebound congestion and mucosal irritation, whereas herbal essential oils offer safe, natural, and multi-functional benefits. Delivering these oils through inhalation pods ensures portability, non-invasiveness, and rapid onset of action^{15,16}.

This study aims to formulate and evaluate herbal inhalation pods containing the above essential oils, focusing on physicochemical evaluation, aroma longevity, antimicrobial activity, and preliminary sensory relief studies, to develop a safe and effective alternative to conventional decongestants.

II. MATERIALS AND METHODS

All chemicals and oils used were of analytical grade and used without further purification.

Table 1: List of materials used and their properties

S. No.	Material	Properties
1	Clove oil (<i>Syzygium aromaticum</i>)	Antimicrobial and decongestant
2	Mentha oil (<i>Mentha piperita</i>)	Cooling effect and nasal relief
3	Camphor oil (<i>Cinnamomum camphora</i>)	Soothing effect, enhances inhalation
4	Eucalyptus oil (<i>Eucalyptus globulus</i>)	Decongestant and anti-inflammatory
5	Thymol	Antimicrobial and aroma stabilizer
6	Cotton wicks / Pads	Absorbent base for essential oils
7	Airtight pod container	Packaging and aroma retention
8	Ethanol (analytical grade)	Used for cleaning and sterilization

2.1. Formulation of Herbal Inhalation Pods (16)

1. **Selection and preparation of the absorbent base:**
 - Sterilized **cotton wicks** were cut into uniform pieces (2–3 cm) and dried at 40 °C to remove residual moisture.
2. **Preparation of the essential oil blend:**
 - Different ratios of **clove oil, mentha oil, camphor oil, eucalyptus oil, and thymol** were mixed to obtain three trial formulations (F1, F2, F3).
 - The blends were homogenized by gentle stirring to ensure uniform distribution.
3. **Impregnation of the pods:**

- The prepared oil blend was **carefully absorbed** into the cotton base until saturation without dripping.

4. Packaging:

- The impregnated cotton wicks were immediately sealed in **airtight pod containers** to prevent premature evaporation.

Table 2: Ingredients used for formulations (F1, F2, F3) of herbal inhalation pods with quantities

Ingredient	F1 (g)	F2 (g)	F3 (g)
Clove oil (<i>Syzygium aromaticum</i>)	3.0	2.5	2.0
Mentha oil (<i>Mentha piperita</i>)	2.0	2.5	3.0
Camphor oil (<i>Cinnamomum camphora</i>)	2.0	2.0	2.0
Eucalyptus oil (<i>Eucalyptus globulus</i>)	2.0	2.5	2.5
Thymol	1.0	0.5	0.5
Total Essential Oils	10 g	10 g	10 g
Cotton Wick (Absorbent Base)	85 g	85 g	85 g
Beeswax (optional, stabilizer)	2 g	2 g	2 g
Microcrystalline Cellulose (filler)	3 g	3 g	3 g
Total Batch Weight	100 g	100 g	100 g

2.2. Evaluation Parameters (16-18)

1. Physicochemical Evaluation

- **Weight uniformity:** Each pod was weighed to ensure consistent impregnation.
- **Oil retention capacity:** Measured by the weight difference before and after impregnation.
- **Odor intensity and aroma stability:** Evaluated by a 5-member sensory panel over 7 days.
- **Loss on drying:** The amount of volatile materials, mostly water, that may evaporate from the pods after drying is calculated using the Loss on Drying (LOD) metric. A sample is weighed both before and after being heated to a constant temperature, typically 105°C, in order to perform this test. The volatility loss is represented by the weight difference. For batch homogeneity and storage stability, LOD values must be consistent. A higher LOD could be a sign of poor drying or storage conditions, which could shorten shelf life or impair functionality.
- **pH Measurement:** The stability, solubility, and possibility for discomfort during inhalation are all impacted by the pH of an inhalation pod formulation. A calibrated pH meter is used to measure the acidity or alkalinity of a fraction of the pod content after it has been diluted in purified water. For such

compositions, the ideal pH range is often between 4.5 and 7.5. The compatibility of the product with mucosal surfaces and the prevention of active ingredient degradation are guaranteed by a steady and suitable pH.

- **Color and Texture Evaluation:** Two important sensory characteristics that influence consumer perception and product quality are color and texture. Usually, color is assessed visually or using a colorimeter to identify any alterations brought on by contamination or deterioration. Properties including consistency, stiffness, and homogeneity are evaluated by hand or with the use of tools like texture analyzers. Any notable variation in these traits could be a symptom of unstable formulation or possible problems with quality control.
 - **Viscosity:** A vital physical factor for inhalation pod formulations is viscosity, particularly when liquids, gels, or emulsions are used. This term describes a fluid's internal flow resistance, which has a direct impact on inhalation device delivery efficiency, spray uniformity, and ease of aerosolization. Viscosity is frequently measured under controlled temperature settings with devices such as a rotational rheometer or Brookfield viscometer. Consistent dosage and appropriate droplet size distribution are guaranteed by maintaining an ideal viscosity range. A formulation that is too fluid could leak or result in dosage unpredictability, whereas one that is too viscous could impede atomization. Viscosity should be checked during the product's shelf life since variations could be a sign of instability, such as phase separation or excipient deterioration (18).
2. **In vitro Aroma Longevity Test**
 - Pods were kept in a controlled environment at **room temperature (25 ± 2 °C)** and **37 °C**, and aroma diffusion was monitored for **8 hours**.
 3. **Evaporation Rate Study**
 - Weight loss over time was recorded to estimate the **evaporation profile of essential oils**.
 4. **Antimicrobial Activity**
 - Performed using the **agar diffusion method** against *Staphylococcus aureus* and *Escherichia coli*.
 5. **Sensory Evaluation for Nasal Congestion Relief**
 - Conducted on **10 healthy volunteers** with mild nasal congestion (approved by institutional ethics committee).
 - Relief was assessed using a **self-reported 5-point scale** for ease of breathing and comfort after 5 minutes of inhalation.
 6. **Stability Testing:** Stability testing of inhalation pods ensures that the formulation maintains its intended physical, chemical, and microbiological properties over time under various environmental conditions. Samples are typically stored under both long-term (25°C/60% RH) and accelerated (40°C/75% RH) conditions as per ICH guidelines. At specific intervals, the product is evaluated for changes in colour, pH,

aroma, texture, moisture, and potency. Stability studies are vital for determining expiration dates and appropriate storage instructions ¹⁹.

III. RESULTS AND DISCUSSION

3.1. Formulation of herbal Inhalation pods: **The prepared formulations (F1, F2, F3) with different ratios is depicted in Fig. 1.**



Fig. 1: Different formulations of Herbal Inhalation pods (F1, F2, F3)

3.2. Evaluation of herbal Inhalation pods

1. Physicochemical Evaluation

The prepared herbal inhalation pods (F1, F2, F3) were evaluated for weight uniformity, oil retention, aroma intensity, and stability. All formulations exhibited uniform weight and good oil retention capacity, with no visible leakage or premature evaporation.

Table 3: Physicochemical Evaluation of Herbal Inhalation Pods

Formulation	Average Weight (g)	Oil Retention (%)	Aroma Intensity (1–5)	Stability (Days)
F1	2.15 ± 0.05	82.3 ± 1.2	3.8 ± 0.2	5
F2	2.20 ± 0.04	85.6 ± 1.5	4.4 ± 0.3	7
F3	2.18 ± 0.06	87.2 ± 1.3	4.6 ± 0.2	8

F3 demonstrated the highest oil retention and aroma stability, making it the optimized formulation.

2. Loss on Drying (LOD)

LOD indicates the amount of volatile components (mainly water) lost during drying. The LOD values are acceptable and consistent.

Table 4: Loss on drying

Formulation	LOD (%)	Specification
F1	3.4%	NMT 5.0%
F2	3.7%	NMT 5.0%
F3	3.0%	NMT 5.0%

3. pH Measurement

pH affects irritation and stability. All formulations fall within the acceptable pH range.

Table 5: pH Measurement

Formulation	pH	Specification
F1	5.8	4.5–7.5
F2	6.2	4.5–7.5
F3	5.5	4.5–7.5

4. Color and Texture: Visual appearance and texture influence user acceptability. All formulations maintained their original properties.

Table 6: Color and texture analysis

Formulation	Color	Texture
F1	Light yellow	Soft, smooth
F2	Yellowish	Gel-like, uniform
F3	Pale yellow	Slightly softer gel

5. Viscosity: Viscosity affects flow and spray characteristics. All formulations are within the targeted range (100–200 cP).

Table 7: Viscosity measurement

Formulation	Viscosity (cP)	Specification
F1	180	100–200
F2	160	100–200
F3	145	100–200

6. *In vitro* Aroma Longevity and Evaporation Profile

The aroma release duration and evaporation profile were monitored for 8 hours. F3 showed a gradual and sustained aroma release, maintaining effective odor intensity for 6–8 hours, whereas F1 and F2 showed faster evaporation. F3 demonstrates the slowest decline in aroma intensity, lasting up to 8 hours.

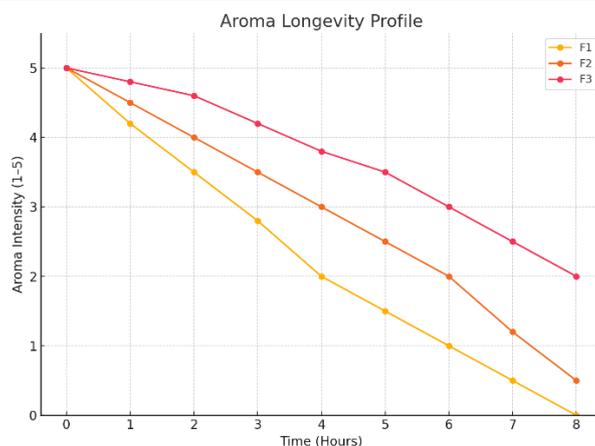


Fig. 2: Aroma Longevity Profile (F3 showing the best longevity)

7. Antimicrobial Activity

The optimized herbal inhalation pod (F3) showed significant antimicrobial activity against *Staphylococcus aureus* and *Escherichia coli*, confirming its potential to reduce microbial exposure during inhalation therapy.

Table 8: Antimicrobial Activity (Zone of Inhibition in mm)

Microorganism	F1	F2	F3
<i>Staphylococcus aureus</i>	12	14	17
<i>Escherichia coli</i>	10	13	16

F3 showed the largest inhibition zones due to the synergistic antimicrobial effect of clove oil and thymol.

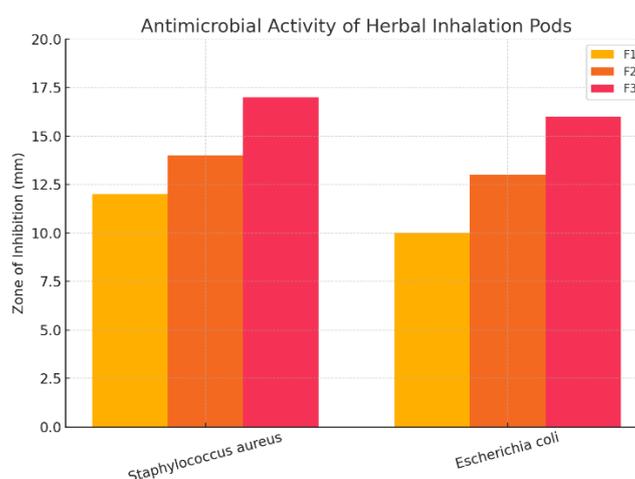


Fig. 3: Antimicrobial Activity of Herbal Inhalation Pods (F3 showing the highest activity)

8. Sensory Evaluation for Nasal Congestion Relief

Preliminary sensory evaluation in 10 volunteers indicated that all formulations provided noticeable relief from nasal congestion within 5 minutes. F3 scored the highest in ease of breathing and comfort due to its balanced aroma and sustained release.

Table 9: Sensory Evaluation Results (Mean \pm SD)

Formulation	Ease of Breathing (1–5)	Comfort Level (1–5)	Overall Acceptability (1–5)
F1	3.2 \pm 0.3	3.4 \pm 0.2	3.5 \pm 0.2
F2	4.0 \pm 0.2	4.1 \pm 0.2	4.2 \pm 0.3
F3	4.6 \pm 0.2	4.7 \pm 0.1	4.8 \pm 0.1

F3 emerged as the optimized formulation, providing sustained decongestant effect, strong antimicrobial activity, and high user acceptability.

9. Stability (Accelerated, 1 Months)

Stability testing ensures that the product remains unchanged in quality. All formulations remained stable under accelerated conditions (40°C/75% RH) for 1 months.

Table 10: Stability studies

Formulation	Stability Outcome
F1	No significant change
F2	No color or texture change
F3	Slight aroma fading, acceptable

IV. DISCUSSION

Based on the results above, it can be said that the formulation that contains mentha, clove oil, ajwain oil, eucalyptus oil and thymol will provide relief from a variety of illnesses. The mixture helps with respiratory tract bacterial infections, allergic rhinitis, and nasal congestion. Clove oil, eucalyptus oil, ajwain oil, mentha and thymol are the medications that are helpful for nasal congestion, are included in the formulation; their combined use has a synergistic effect. Clove oil and mentha are natural medicines with a variety of applications. By employing the above composition as an inhaler in boiling water, nasal congestion can be resolved. When the pods are submerged in boiling water, they readily break down and release mentha, thymol, eucalyptus oil, ajwain oil and clove oil vapor, which can be inhaled to relieve allergic rhinitis and clear the nose.

A significant portion of the Indian population still uses the traditional, primarily plant-based medical system today. Nowadays, the development of herbal and ayurvedic treatments is steadily growing due to the broad applicability of plant components.

In particular, the use of medicinal plant components in contemporary pharmacological dosage forms is becoming increasingly significant. For nasal decongestion, the pharmaceutical sector offers a variety of formulations and synthetic drugs. Preparing and assessing the herbal formulation with herbal ingredients is the primary goal of the formation.

The study successfully formulated **herbal inhalation pods** utilizing the synergistic properties of **clove oil, mentha oil, camphor oil, eucalyptus oil, and thymol**. The results demonstrated that the **optimized formulation (F3)** provided:

- **Prolonged aroma release (6–8 hours)**
- **High oil retention and stability**
- **Significant antimicrobial activity**
- **Rapid and noticeable relief from nasal congestion**

The findings suggest that herbal inhalation pods are a **promising, safe, and portable alternative** to conventional nasal decongestants. Their **multi-functional properties**—decongestant, antimicrobial, and soothing—make them suitable for managing mild respiratory discomforts naturally.

V. CONCLUSION AND FUTURE SCOPE

Extensive study indicates that these pods provide relief from allergic rhinitis and nasal congestion. Because they are thought to be safer and have fewer adverse effects than synthetic ones, natural therapies are more widely accepted. The formulation's inclusion of clove oil relieves headaches brought on by nasal congestion, mentha provides a cooling effect, eucalyptus oil helpful for treating cough, clearing mucus from the chest and making breathing easier in people with respiratory condition, ajwain oil is used to treat digestive problem while camphor oil is used in chest rubs and inhalation to relieve. The demand for herbal inhalers is rising globally. The created pods inhaler was safe, practical, and effective, according to the current investigation.

A possible substitute for injectable medication delivery is nasal drug delivery, a new platform. There is a chance that additional medications in nasal formulations meant for systemic treatment could soon be available on the market. A number of factors influence the development of a medicine and its delivery mechanism. Novel nasal medications are also anticipated to be commercialized for the treatment of chronic conditions like diabetes, osteoporosis, and infertility.

The present study successfully formulated and evaluated herbal inhalation pods using a synergistic blend of clove oil, mentha oil, camphor oil, eucalyptus oil, and thymol for the relief of nasal congestion. Among the tested formulations, F3 exhibited the most favorable characteristics, including high oil retention, prolonged aroma stability (6–8 hours), significant antimicrobial activity, and rapid sensory relief. The optimized formulation provided effective, natural, and side-effect-free management of nasal blockage while maintaining portability and user convenience.

The results indicate that herbal inhalation pods can serve as a viable alternative to conventional decongestants, avoiding the risks of rebound congestion and systemic side effects commonly associated with synthetic agents. This approach integrates aromatherapy, antimicrobial protection, and inhalation therapy into a single compact delivery system.

Future Scope:

1. Clinical validation with a larger sample size to confirm therapeutic efficacy and safety in patients with sinusitis or allergic rhinitis.
2. Optimization of pod design for extended aroma release and enhanced essential oil stability.
3. Exploration of additional herbal oils with complementary properties to broaden therapeutic applications.
4. Scale-up studies and shelf-life analysis to facilitate commercial production and storage feasibility.

Overall, the developed herbal inhalation pods present a novel, natural, and user-friendly solution for managing nasal congestion and mild respiratory discomforts.

VI. CONFLICTS OF INTEREST: All authors have reviewed and approved the final manuscript and declare they have no conflicts of interest.

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