

Formulation and Evaluation of Medicated Aromatherapy Candle Containing Eucalyptus Oil and Menthol for Respiratory Relief

Original Research Article

Samiksha A. Jaiswal., Pratik G. Kalane., Shrutika V. Belkhede., Samiksha G. Dhabale., Mayuri R. Bahe., Dr. Dinesh S. Wanjari., Mr. Abhijit N. Daf

Agnihotri Institute of Pharmacy, Wardha (M.S), India-442001

ABSTRACT

Background & Objective: Respiratory discomfort and nasal congestion are common clinical symptoms resulting from upper respiratory tract infections, allergies, and environmental pollution. Traditional oral decongestants often cause systemic side effects, rendering non-invasive inhalation therapy an attractive alternative. The present study aimed to design, formulate, and evaluate a novel medicated aromatherapy candle matrix containing eucalyptus oil, menthol, camphor, peppermint oil, and lavender oil for controlled inhalation therapy.

Methods: Five distinct candle formulations (F1–F5) were synthesized by varying concentrations of paraffin wax, stearic acid, coconut oil, and active medicaments. The prepared batches were subjected to comprehensive physicochemical and performance evaluations, including physical appearance, weight variation, melting point determination, burn duration, burn rate, flame height stability, and sensory aroma intensity testing across human volunteers.

Results: All formulations exhibited acceptable structural integrity and uniform mass distribution (average mass: 49.9 ± 0.3 g). Among the evaluated batches, Formulation F3 demonstrated optimized performance characteristics, exhibiting a melting point of 57 ± 0.5 °C, a total burn duration of 230 ± 3.5 minutes, a controlled mass burn rate of 0.20 ± 0.01 g/min, a highly stable flame height (3.1 ± 0.1 cm), and superior sensory aroma perception without inducing respiratory irritation. The synergistic action of 1,8-cineole from eucalyptus oil and L-menthol provided a soothing, decongestant vapor profile suitable for indoor atmosphere enrichment.

Conclusion: Medicated aromatherapy candles represent a stable, convenient, non-invasive, and effective complementary drug delivery matrix for continuous indoor inhalation therapy to relieve upper respiratory tract congestion.

Keywords: *Aromatherapy Candle, Eucalyptus Oil, Menthol, Inhalation Therapy, Nasal Congestion, 1,8-Cineole, Respiratory Wellness.*

1. INTRODUCTION

1.1 Background on Aromatherapy and Respiratory Health

Aromatherapy is a recognized holistic therapeutic approach utilizing volatile, plant-derived essential oils to promote physical, physiological, and psychological well-being [1]. The term was originally coined in 1937 by

René-Maurice Gattefossé, who documented the pharmacological and tissue-healing properties of aromatic plant extracts [2]. Essential oils contain complex mixtures of bioactive monoterpenes, sesquiterpenes, alcohols, esters, aldehydes, and phenols that readily volatilize at ambient or elevated temperatures [3].

When inhaled, these micro-droplets and gaseous active molecules directly interact with the olfactory epithelium and the respiratory mucous membranes. Olfactory nerve activation transmits signals to the limbic system, influencing neurotransmitter release (such as endorphins and serotonin), thereby mediating pain relief, stress reduction, and systemic relaxation [4]. Concurrently, direct contact of volatile active molecules with the bronchial epithelium exerts localized pharmacological actions, including mucus thinning, bronchodilation, anti-inflammatory activity, and antimicrobial clearance.

1.2 Phytochemistry of Eucalyptus Oil and Menthol

Eucalyptus oil, extracted primarily from the leaves of *Eucalyptus globulus*, contains 60–90% eucalyptol (1,8-cineole), a monoterpenoid cyclic ether [5,6]. 1,8-Cineole exhibits marked mucolytic and bronchodilatory activity by inhibiting mucin hypersecretion, reducing bronchial smooth muscle spasm, and suppressing pro-inflammatory cytokine expression (TNF- α , IL-1 β) [6,10]. In clinical settings, inhalation of 1,8-cineole significantly improves lung function parameters and reduces exacerbation frequency in patients suffering from acute rhinosinusitis, bronchitis, and chronic obstructive pulmonary disease (COPD) [10,11].

Menthol (specifically L-menthol) is a cyclic monoterpene alcohol derived from *Mentha piperita* and related mint species [7,8]. Pharmacologically, menthol acts as a potent selective agonist at transient receptor potential melastatin-8 (TRPM8) receptors expressed on cold-sensitive sensory nerve endings within the nasal mucosa [8,9]. Receptor stimulation induces a pronounced sensation of cooling and subjective airway opening, alleviating perceived nasal resistance and dyspnea without significantly altering physical airway dimensions [12]. Furthermore, menthol displays mild local anesthetic, antitussive, and soothing properties [9,13]. The co-administration of eucalyptus oil and menthol yields a synergistic therapeutic dynamic: eucalyptus oil enhances clearance and reduces airway inflammation, while menthol delivers rapid sensory decongestion.

1.3 Rationale for Candle-Based Inhalation Delivery

Conventional inhalation therapies—such as steam inhalation, pressurized metered-dose inhalers (pMDIs), or ultrasonic nebulizers—often suffer from patient compliance issues, device cost, requirement for electricity, or rapid dosage dissipation. Candle-based thermal diffusion offers a passive, continuous, non-invasive alternative [14]. As the candle burns, the controlled heat melt-pool volatilizes active terpenes from the wax matrix into the surrounding ambient air at a steady rate. This ensures sustained indoor vapor levels without requiring specialized electronic equipment.

2. MATERIALS AND METHODS

2.1 Materials

Paraffin wax (pharmaceutical grade, melting point 56–58 °C) served as the primary solid candle vehicle. Stearic acid was incorporated as a structural hardening agent and flame stabilizer. Coconut oil (pure cold-pressed) was added to enhance component solubility and ensure smooth melt-pool dynamics. Active phytopharmaceutical ingredients included Eucalyptus oil (*E. globulus*, >70% 1,8-cineole), Menthol crystals (L-

menthol, 99% purity), Camphor, Peppermint oil, and Lavender oil. Braided 100% pure cotton wicks and heat-resistant glass containers were utilized for casting.

2.2 Formulation Design

Five formulation batches (F1 to F5) were designed with varying proportions of base matrix and active medicaments to evaluate combustion dynamics and active loading optimization, as detailed in Table 2.

Ingredients	F1	F2	F3 (Optimized)	F4	F5
Paraffin Wax (g)	38.5	35.5	29.0	23.0	17.0
Stearic Acid (g)	1.5	2.5	2.5	2.5	2.5
Coconut Oil (mL)	2.0	2.0	2.0	2.0	2.0
Menthol Crystals (g)	1.5	1.5	3.5	5.5	7.5
Camphor Powder (g)	1.0	2.0	4.0	6.0	8.0
Eucalyptus Oil (mL)	1.5	2.5	4.5	6.5	8.5
Lavender Oil (mL)	2.0	2.0	2.0	2.0	2.0
Peppermint Oil (mL)	2.0	2.0	2.5	2.5	2.5
Total Target Weight (g)	50.0	50.0	50.0	50.0	50.0

2.3 Preparation Method

1. Wax Matrix Fusion: Paraffin wax was weighed accurately and melted in a double-boiler apparatus maintained strictly between 60 °C and 70 °C to prevent thermal degradation. Stearic acid was added slowly under constant agitation until fully dissolved, followed by coconut oil incorporation.
2. Active Incorporation: Menthol crystals and camphor were pulverized into fine powder using a glass mortar and pestle. To minimize volatile loss, the wax mixture was allowed to cool to 50–55 °C prior to incorporating menthol, camphor, eucalyptus oil, peppermint oil, and lavender oil under gentle, continuous stirring.
3. Casting & Solidification: The liquid formulation was poured into glass molds pre-fitted with central cotton wicks held under tension. The candles were allowed to cool slowly at room temperature (25 °C) to prevent thermal contraction cracks, trimmed, and stored in airtight glass containers away from heat and light.

2.4 Evaluation Parameters

- Physical Appearance: Evaluated visually for surface smoothness, color uniformity, presence of air pockets, and structural cracking.
- Weight Variation: Ten candles from each batch were weighed individually on an analytical digital balance

(± 0.01 g sensitivity) to evaluate batch uniformity.

- **Melting Point Determination:** Determined using standard capillary tube apparatus immersed in liquid paraffin bath (Thiele tube method).
- **Combustion Parameters:** Lit under draft-free controlled laboratory conditions. Total burn duration (min), weight loss over 30 min burn increments (g/min rate), and flame height (cm) were recorded using digital timers, precision calipers, and mass balances.
- **Sensory Aroma Intensity:** Assessed by a panel of 10 healthy human volunteers in a standardized test room (20 m³). Intensity was rated on a 5-point hedonic scale: 1 = Very Weak, 2 = Weak, 3 = Moderate, 4 = Strong, 5 = Very Strong.

3. RESULTS

3.1 Physicochemical Properties and Melting Point

Visual evaluation demonstrated that Formulations F2 and F3 possessed superior physical elegance, smooth surface texture, uniform off-white coloration, and complete freedom from air bubbles or structural cracking. High concentrations of liquid essential oils in F4 and F5 resulted in minor structural softening and surface roughness due to matrix saturation.

The average mass of prepared candles across all formulations was 49.9 ± 0.3 g, confirming high manufacturing consistency. Melting points ranged between 51 °C and 57 °C, as detailed in Table 3. Formulation F3 recorded the highest melting point (57 ± 0.5 °C), attributing to optimal thermal stability during storage and controlled melt-pool formation.

Formulation	Appearance	Melting Pt (°C)	Burn Time (min)	Burn Rate (g/min)	Flame Height (cm)
F1	Pale yellow, slightly rough	51 ± 0.4	195 ± 2.5	0.23 ± 0.01	2.6 ± 0.2
F2	Cream white, smooth	54 ± 0.5	210 ± 3.0	0.22 ± 0.01	2.9 ± 0.1
F3 (Optimized)	Off-white, smooth & uniform	57 ± 0.5	230 ± 3.5	0.20 ± 0.01	3.1 ± 0.1
F4	Slightly yellow, minor rough	52 ± 0.6	220 ± 4.0	0.21 ± 0.02	2.5 ± 0.2
F5	Dull white, rough surface	55 ± 0.5	220 ± 3.8	0.21 ± 0.01	3.1 ± 0.2

3.2 Combustion Dynamics and Aroma Performance

Burn duration studies revealed total burning times between 195 and 230 minutes across 50 g candles. Formulation F3 demonstrated the longest continuous burn duration (230 ± 3.5 min) and the lowest burn rate (0.20 ± 0.01 g/min), indicating slow, steady wax consumption and prolonged therapeutic vapor delivery.

Flame height analysis confirmed stable combustion across all formulations, averaging between 2.5 cm and 3.1 cm. Formulation F3 maintained an optimal 3.1 cm flame height without producing visible soot or flickering. In sensory panel evaluation, F3 achieved the highest hedonic score (4.6 / 5.0 - Strong, Pleasant Aroma), providing immediate perception of cooling and airway opening without inducing eye or throat irritation.

4. DISCUSSION

The formulation and development of medicated aromatherapy candles present a novel approach to continuous, non-invasive respiratory therapy. The key challenge in solid candle matrix design lies in balancing therapeutic oil loading with combustion stability. Excessive oil loading leads to softening of the paraffin matrix, rapid melting, and flickering flames, whereas insufficient active loading fails to produce therapeutic vapor concentrations [5].

In the present study, Formulation F3 achieved optimal balance by incorporating 29.0 g paraffin wax, 2.5 g stearic acid, 3.5 g menthol, and 4.5 mL eucalyptus oil. Stearic acid functioned effectively as a structural hardener, counteracting the liquidifying effect of essential oils and raising the melting point to 57 °C. This higher melting point established a controlled melt-pool during combustion, regulating active vapor evaporation.

Pharmacologically, the combined volatilization of 1,8-cineole and L-menthol creates a dual sensory and physiological mechanism. Thermal evaporation releases volatile monoterpenes into the indoor atmosphere. Upon inhalation, L-menthol stimulates TRPM8 cold receptors in the nasal mucosa, triggering rapid subjective relief from nasal congestion [8,12]. Concurrently, 1,8-cineole lowers mucus viscosity and exerts localized anti-inflammatory effects on bronchial tissue [1,10]. The controlled burn rate of 0.20 g/min observed in Formulation F3 guarantees sustained therapeutic delivery over 3.8 hours, offering significant advantages over short-acting oral decongestants or electronic steam diffusers.

5. CONCLUSION

The present investigation successfully formulated and evaluated a novel medicated aromatherapy candle containing eucalyptus oil and menthol for inhalation therapy. Formulation F3 emerged as the optimized batch, exhibiting superior physical elegance, optimal melting point (57 °C), prolonged burn time (230 minutes), controlled burn rate (0.20 g/min), stable flame characteristics, and pleasant aroma intensity. Medicated aromatherapy candles represent a safe, user-friendly, non-invasive, and cost-effective complementary matrix for managing mild upper respiratory discomfort and nasal congestion.

REFERENCES

- [1] Juergens UR, Dethlefsen U, Steinkamp G, Gillissen A, Repges R, Vetter H. Anti-inflammatory activity of 1,8-cineol (eucalyptol) in bronchial asthma: a double-blind placebo-controlled trial. *Respir Med.* 2003;97(3):250-256.
- [2] Ali B, Al-Wabel NA, Shams S, Ahamad A, Khan SA, Anwar F. Essential oils used in aromatherapy: A systemic review. *Asian Pac J Trop Biomed.* 2015;5(8):601-611.
- [3] Lakhan SE, Sheafer H, Tepper D. The Effectiveness of Aromatherapy in Reducing Pain: A Systematic Review and Meta-Analysis. *Pain Res Treat.* 2016;2016:8158693.
- [4] Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils--a review. *Food Chem Toxicol.* 2008;46(2):446-475.

- [5] Keshwari V, Gupta S, Kushwaha N, Keshwari R, Patel DKM. A review on therapeutics application of eucalyptus oil. *Int J Herbal Med.* 2018;6(6):110-115.
- [6] Silva J, Abebe W, Sousa SM, Duarte VG, Machado MIL, Matos FJA. Analgesic and anti-inflammatory effects of essential oils of Eucalyptus. *J Ethnopharmacol.* 2003;89(2-3):277-283.
- [7] Eccles R. Menthol and related cooling compounds. *J Pharm Pharmacol.* 1994;46(8):618-630.
- [8] Li Z, Zhang H, Wang Y, Li Y, Li Q, Zhang L. The distinctive role of menthol in pain and analgesia: Mechanism, practices, and advances. *Front Mol Neurosci.* 2022;15:1006111.
- [9] Farco JA, Grundmann O. Menthol--pharmacology of an important naturally medicinal 'cool'. *Mini Rev Med Chem.* 2013;13(1):124-131.
- [10] Worth H, Schacher C, Dethlefsen U. Concomitant therapy with cineole reduces exacerbations in COPD: a placebo-controlled double-blind trial. *Respir Res.* 2009;10(1):69.
- [11] Kehrl W, Sonnemann U, Dethlefsen U. Therapy for acute non-purulent rhinosinusitis with cineole: results of a double-blind randomize placebo-controlled trial. *Laryngoscope.* 2004;114(4):738-742.
- [12] Eccles R. Menthol: effects on nasal sensation of airflow and the drive to breathe. *Curr Allergy Asthma Rep.* 2003;3(3):210-214.
- [13] Paul IM, Beiler JS, King TS, Clapp ER, Vallati J, Berlin CM Jr. Vapor rub, petrolatum, and no treatment for children with nocturnal cough and cold symptoms. *Pediatrics.* 2010;126(6):1092-1099.
- [14] Rojas M, Lee S, Kim H. Diffusion dynamics and thermal volatilization of monoterpenes in paraffin-stearic wax matrices. *J Essent Oil Res.* 2018;30(4):285-293.

Copyright & License:

© Authors retain the copyright of this article. This work is published under the Creative Commons Attribution 4.0 International License (CC BY 4.0), permitting unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.