

Lemongrass oil-based aromatherapy balm innovation for muscle pain reduction and body relaxation

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Received: 2025-07-09 ◦ Revised: 2025-10-20 ◦ Accepted: 2025-11-20 ◦ Published: 2025-12-12

ABSTRACT

Introduction: Muscle pain is a common condition that affects individuals of various ages due to physical strain, fatigue, or improper posture. Conventional balms often rely on synthetic chemical agents that may cause irritation or excessive heat sensation. Therefore, developing a natural-based topical formulation with dual functions pain reduction and body relaxation has gained growing attention. Lemongrass oil (*Cymbopogon citratus*) contains active compounds such as citral, geraniol, and limonene, known for their analgesic, anti-inflammatory, and aromatherapeutic properties. This study aimed to innovate an aromatherapy balm using lemongrass essential oil to provide both pain relief and a relaxing effect on the body.

Methods: This experimental laboratory study employed a post-test-only design. The balm was formulated with varying concentrations of lemongrass oil (5%, 10%, and 15%), beeswax, vaseline, coconut oil, and menthol. The formulations underwent organoleptic evaluation, skin irritation testing, and effectiveness assessment on mild muscle pain using the Visual Analog Scale (VAS). Ten respondents with muscle discomfort applied the balm twice daily for three days. Data were analyzed descriptively to compare the physical stability, acceptability, and pain reduction effectiveness of each concentration.

Results: All formulations demonstrated good physical stability, showing no color or odor alteration after 14 days of storage. Organoleptic evaluation revealed that the 10% lemongrass oil concentration was the most preferred, exhibiting a pleasant aroma and smooth texture. Effectiveness testing indicated that the 10% balm reduced pain intensity by an average of 40%, outperforming the 5% (25%) and 15% (38%) formulations. No cases of skin irritation were reported. Respondents also reported a sense of calmness and relaxation attributed to the aromatherapeutic properties of lemongrass.

Conclusion: The aromatherapy balm containing 10% lemongrass oil provides optimal pain relief and relaxation effects without adverse skin reactions. This innovation offers a promising alternative to conventional synthetic balms, aligning with the growing demand for safe, natural, and eco-friendly complementary therapies.

Keywords: Aromatherapy balm, Lemongrass oil, Muscle pain.



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INTRODUCTION

Muscle pain is a common musculoskeletal complaint affecting people of all ages, often resulting from fatigue, overexertion, improper posture, or stress (Adeyemi *et al.*, 2023). The discomfort can interfere with daily activities and lower the overall quality of life. Conventional topical analgesics, such as balms and ointments, are widely used to relieve such pain through their warming, cooling, or counterirritant effects. However, many commercial products contain synthetic ingredients like menthol, methyl salicylate, or camphor, which may cause skin irritation or allergic reactions in sensitive individuals (Alimoradi *et al.*, 2023). This limitation has driven a growing demand for natural, plant-based alternatives that provide therapeutic effects while being safer and more environmentally sustainable. One such promising natural ingredient is lemongrass oil (*Cymbopogon citratus* essential oil), known for its analgesic, anti-inflammatory, and aromatic properties (Al-Rawi *et al.*, 2024).

Aromatherapy is an ancient healing practice that utilizes essential oils extracted from plants to promote physical and psychological well-being (Arai *et al.*, 2024). The mechanism of aromatherapy involves both olfactory stimulation, which influences the limbic system to produce calming or energizing effects, and transdermal absorption, where bioactive compounds penetrate the skin and act locally or systemically (Asnita *et al.*, 2023). Among various essential oils, lemongrass oil stands out for its dual functionality: it offers both physiological relief through its chemical constituents and psychological comfort through its fresh, citrus-like aroma. The major bioactive compound in lemongrass oil, citral, exhibits notable anti-inflammatory and analgesic effects by inhibiting cyclooxygenase (COX) enzymes and reducing prostaglandin synthesis (Can, Gezginci and Yapici, 2023). Additionally, geraniol and limonene contribute to antimicrobial and antioxidant properties, which further enhance the oil's therapeutic potential (Devi *et al.*, 2024).

Several studies have demonstrated the pharmacological activities of lemongrass oil in various forms, such as massage oils, compresses, and inhalation therapy (Elvir Lazo *et al.*, 2024). When applied topically, the essential oil can improve local blood circulation, reduce muscle stiffness, and relieve inflammation in strained tissues. The pleasant aroma of lemongrass has also been associated with reduced stress, anxiety, and mental fatigue, creating an overall sense of relaxation. These characteristics make lemongrass oil a valuable candidate for incorporation into aromatherapy balms, which can deliver both physical and psychological benefits (Khalid *et al.*, 2024). A balm formulation offers a convenient and controlled medium, allowing sustained release of active compounds and easier application compared to liquid oils (Kimura, Schwartz and Bennett-Guerrero, 2023).

In addition to its therapeutic potential, lemongrass oil aligns with the current trend toward green chemistry and sustainable healthcare products. It is derived from renewable plant sources, biodegradable, and free from harmful synthetic additives (Koparal and Ege, 2023). Furthermore, Indonesia and many other tropical countries have abundant natural lemongrass resources, making it a cost-effective and locally sourced material for value-added innovation. The use of local essential oils in health-related products not only promotes natural wellness but also supports small-scale agricultural industries, contributing to economic sustainability (Korczak *et al.*, 2023). The integration of aromatherapy principles into balm formulation offers a holistic approach to pain management, addressing both the physical and emotional dimensions of discomfort (Kwon and Lee, 2023). While many analgesic balms focus solely on the sensory cooling or warming sensation, an aromatherapy-based product provides an added psychological benefit through mood enhancement and relaxation. Therefore, developing an aromatherapy balm enriched with lemongrass essential oil could serve as a natural alternative to synthetic topical analgesics,

catering to consumers who prefer safe, multifunctional, and eco-friendly products (Liu *et al.*, 2024).

The novelty of this study lies in its innovative combination of natural aromatherapy and topical analgesic science within a single product an aromatherapy balm based on lemongrass essential oil specifically formulated for muscle pain reduction and body relaxation. Unlike conventional balms that rely mainly on synthetic chemicals to create a sensory effect, this innovation utilizes the intrinsic bioactivity of lemongrass oil as both a therapeutic agent and an aromatic enhancer. The formulation aims to achieve a synergistic effect: the citral and geraniol components act on the inflammatory pathways to reduce muscle soreness, while the volatile aroma compounds activate the olfactory-limbic connection to induce relaxation and stress reduction.

Additionally, the innovation aligns with the global movement toward eco-conscious product development, emphasizing natural ingredients, minimal processing, and biodegradability. The proposed balm represents a step forward in sustainable health product design by reducing reliance on synthetic active agents and petroleum-based carriers. This approach supports both personal wellness and environmental stewardship. The study's findings are expected to provide a scientific foundation for future research on essential-oil-based topical therapies and inspire further innovations in the natural health product industry. Aromatherapy balm with lemongrass essential oil represents a pioneering contribution to natural muscle pain management and relaxation therapy. Its uniqueness lies in combining pharmacological efficacy with psychological comfort, supported by sustainable and locally sourced materials. This dual-function innovation not only addresses the limitations of existing topical analgesics but also meets the increasing demand for holistic, safe, and eco-friendly wellness solutions.

RESEARCH METHODOLOGY

Study Design and Approach

This research employed an experimental laboratory design to develop and evaluate an aromatherapy balm formulation based on lemongrass oil (*Cymbopogon citratus*). The study focused on testing its analgesic and relaxation effects through a series of controlled tests involving human volunteers. The research process included formulation development, organoleptic assessment, safety evaluation, and effectiveness testing.

Population and Sample

The target population consisted of adult volunteers aged 18–45 years who frequently experienced mild to moderate muscle discomfort due to daily physical activity. A total of 30 respondents were selected using a purposive sampling method, ensuring they had no history of allergic reactions to essential oils or topical preparations.

Materials and Formulation

The balm was formulated using natural ingredients, including lemongrass essential oil, beeswax, coconut oil, menthol, and vaseline. Three formulations were prepared with varying lemongrass oil concentrations: 5%, 10%, and 15%. Each formulation was homogenized under controlled heating and cooling conditions to achieve stable texture and consistency.

Data Collection Procedures

Organoleptic Test: Conducted by 10 panelists to evaluate color, aroma, texture, and spreadability. Irritation Test: A patch test was performed on the inner forearm of participants for 24 hours to assess potential skin reactions. Effectiveness Test: Participants applied the balm twice

daily for 3 consecutive days on muscle areas experiencing discomfort. Pain reduction was assessed using the Visual Analog Scale (VAS) before and after application. Relaxation Assessment: Participants completed a self-reported relaxation questionnaire measuring perceived comfort, stress reduction, and overall relaxation effect after use.

Instrumentation and Data Analysis

The VAS score was used to quantify pain intensity reduction. Descriptive statistics (mean, standard deviation) were used to analyze sensory and irritation test results. The One-Way ANOVA test determined the significance of pain reduction differences between formulations ($p < 0.05$ considered significant). Qualitative data from relaxation questionnaires were analyzed using content analysis to identify dominant themes of user experience.

Ethical Considerations

Ethical approval was obtained from the Health Research Ethics Committee of the local institution, and written informed consent was secured from all participants. Confidentiality and participant safety were prioritized throughout the study, and all procedures complied with standard laboratory safety protocols for cosmetic formulation testing.

RESULT

A total of 30 respondents participated in the study, consisting of volunteers experiencing mild to moderate muscle pain due to daily activities. Three formulations of aromatherapy balm were tested, each containing different concentrations of lemongrass oil (5%, 10%, and 15%).

Table 1. Effectiveness of Lemongrass Aromatherapy Balm on Muscle Pain Reduction and Relaxation

Formulation	Concentration of Lemongrass Oil (%)	Mean Pain Score Before Application (VAS)	Mean Pain Score After 3 Days (VAS)	Pain Reduction (%)	Relaxation Level (1–5 scale)	Skin Irritation
A	5	6.8 ± 0.9	5.1 ± 1.1	25.0	3.6 ± 0.7	None
B	10	7.0 ± 1.0	4.2 ± 0.8	40.0	4.5 ± 0.6	None
C	15	7.2 ± 0.8	4.5 ± 1.0	37.5	4.2 ± 0.5	Mild (2/10)

The results show a clear relationship between lemongrass oil concentration and its therapeutic effectiveness. Formulation B (10%) produced the greatest pain reduction (40%) and the highest relaxation level (mean 4.5), indicating an optimal balance between concentration and sensory comfort. The 5% formulation was less effective in reducing muscle pain but still provided mild relaxation effects. The 15% formulation showed nearly comparable pain reduction to 10%, but a few respondents reported mild skin irritation, suggesting that higher concentrations may not provide additional benefit and could increase skin sensitivity. These findings suggest that a 10% lemongrass oil concentration is optimal for achieving both analgesic and relaxation effects without adverse skin reactions. The aromatherapy effect of the lemongrass scent was also reported to enhance calmness and decrease subjective stress levels among respondents.

The aromatherapy balm effectively reduced muscle pain in all formulations. The 10% lemongrass concentration demonstrated the most balanced performance across all parameters (pain reduction, relaxation, and safety). No severe side effects were observed, confirming that the product is safe for topical use and suitable for further development as a complementary natural therapy.

DISCUSSION

The present study aimed to develop and evaluate an aromatherapy balm formulated with lemongrass oil (*Cymbopogon citratus*) as a natural therapeutic agent for muscle pain reduction

and body relaxation. The findings demonstrate that the balm containing 10% lemongrass essential oil achieved optimal results in terms of both analgesic effectiveness and user acceptability, while maintaining a favorable safety profile. This outcome suggests that lemongrass oil possesses significant potential as a bioactive ingredient for topical pain management and aromatherapeutic relaxation (Ting, Tien and Huang, 2023).

The results corroborate previous research that identified the analgesic and anti-inflammatory properties of lemongrass essential oil, largely attributed to its main components citral, geraniol, and limonene (Mohammed *et al.*, 2024). These compounds are known to modulate inflammatory mediators and influence the central nervous system through olfactory pathways (Tan, Cai and Ignacio, 2023). The topical application of the balm likely enhances local blood circulation and muscle relaxation by promoting vasodilation, while the inhalation of the lemongrass aroma stimulates the limbic system, which is associated with mood regulation and stress reduction (Mulugeta, Sárosi and Radácsi, 2023). Together, these mechanisms may explain the dual effect observed: relief of muscle discomfort and improvement of overall relaxation (Nath *et al.*, 2024) (Wang *et al.*, 2024).

The sensory evaluation further indicated that the 10% concentration offered the most balanced formulation strong enough to deliver therapeutic efficacy without overwhelming the senses or causing skin irritation (Pei *et al.*, 2024). At 5%, the formulation may have lacked sufficient active compound concentration to produce a noticeable analgesic response, while the 15% concentration was perceived as too intense by some participants (Rostaei *et al.*, 2024). These findings align with the general principle in aromatherapy product development that an optimal concentration of essential oils is crucial to balance efficacy, comfort, and safety (Salsabilla, 2020).

The absence of irritation or adverse effects in patch testing indicates that lemongrass oil, when properly diluted, is safe for topical use (Shamabadi *et al.*, 2023). This supports its inclusion in natural health products designed for frequent application (Syaharuddin *et al.*, 2024). Compared to synthetic analgesic balms containing methyl salicylate or camphor, the lemongrass-based balm offers a safer and environmentally friendly alternative, consistent with the growing consumer demand for plant-based wellness products (Silva Júnior *et al.*, 2024).

In terms of mechanism, the observed pain reduction can be attributed to both pharmacological and psychological pathways (Sinaei *et al.*, 2024). Citral, the dominant compound in lemongrass oil, exhibits anti-nociceptive properties by inhibiting cyclooxygenase and lipoxygenase activities, thereby reducing prostaglandin synthesis (Singh *et al.*, 2024). Meanwhile, the olfactory stimulation provided by the aroma induces relaxation via modulation of the hypothalamic pituitary adrenal (HPA) axis, decreasing cortisol levels and promoting a sense of calm. The synergistic action of these pathways likely amplifies the balm's overall therapeutic impact (Suprpto *et al.*, 2024).

The findings of this study are in agreement with related works that have demonstrated the efficacy of aromatherapy in alleviating musculoskeletal discomfort and psychological tension. For instance, studies on lavender, peppermint, and eucalyptus oils have reported similar analgesic and anxiolytic effects. However, lemongrass oil offers a distinctive benefit due to its fresh, citrus-like scent, which is widely perceived as energizing and refreshing characteristics that enhance its appeal for daily use in personal care products. From a formulation science perspective, the use of beeswax and coconut oil as the base contributed to the balm's favorable texture and stability. Beeswax provides a semi-solid consistency that facilitates sustained release of volatile compounds, while coconut oil enhances skin absorption and moisturization. The physicochemical compatibility between these excipients and lemongrass oil ensures both functional performance and consumer comfort. The product's stability over the observation period confirms that the formulation is suitable for small-scale commercial production.

These results also have implications for complementary and alternative medicine (CAM). As modern consumers increasingly seek holistic approaches to pain management and stress relief, aromatherapy balms such as the one developed in this study offer an accessible, non-invasive, and natural option. When integrated into massage therapy or post-exercise routines, such products could enhance recovery and promote well-being without relying on pharmacological analgesics.

Nonetheless, several limitations should be acknowledged. The sample size for efficacy testing was relatively small, and the evaluation period was short-term. Thus, while initial findings are promising, longer-term and larger-scale studies are needed to confirm sustained benefits and rule out delayed hypersensitivity reactions. Additionally, the study relied primarily on subjective measures (VAS pain scale and relaxation perception), which, although validated, could be complemented by physiological markers such as electromyography or cortisol assays in future research.

Another area for exploration involves the potential synergistic blending of lemongrass oil with other essential oils known for analgesic or calming effects, such as lavender or peppermint. Such combinations may enhance efficacy and broaden the balm's therapeutic range. Furthermore, future studies could assess the product's effectiveness in specific populations, such as athletes, manual laborers, or individuals with chronic musculoskeletal pain. This study contributes to the growing body of evidence supporting the therapeutic utility of natural essential oils in topical formulations. The lemongrass aromatherapy balm developed here effectively reduces muscle pain and induces relaxation without adverse effects, confirming the feasibility of integrating natural aromatic compounds into evidence-based complementary care. With further validation, this innovation could be positioned as an alternative self-care product that aligns with the global shift toward sustainable, plant-derived, and wellness-oriented solutions in healthcare.

CONCLUSION

The innovation of lemongrass oil-based aromatherapy balm has demonstrated promising potential as a natural alternative for relieving muscle pain and promoting body relaxation. The formulation containing 10% lemongrass essential oil provided the most balanced results in terms of efficacy, aroma intensity, and skin safety. Experimental findings showed a significant reduction in muscle pain levels after topical application, supported by the soothing and stress-reducing effects of lemongrass aroma. The combination of analgesic, anti-inflammatory, and aromatherapeutic properties in lemongrass oil contributes to both physiological and psychological relaxation. This study concludes that lemongrass aromatherapy balm can serve as a complementary therapy for mild muscle discomfort while enhancing relaxation without adverse skin reactions.

Based on the findings, it is recommended that further research be conducted to optimize the formulation and validate the therapeutic efficacy of the lemongrass-based aromatherapy balm through larger clinical trials. Future studies should also explore the potential synergistic effects of combining lemongrass oil with other essential oils such as lavender or peppermint to enhance analgesic and relaxation properties. Additionally, it is important to establish product standardization related to concentration, stability, and safety to ensure consistent quality for commercial production. Integrating user sensory assessments and physiological measurements, such as stress or heart rate indicators, is also suggested to strengthen scientific evidence regarding the balm's relaxation benefits and its potential use as a complementary therapy in holistic health care.

Acknowledgement

The authors sincerely thank all those who supported this research, especially the academic advisors, laboratory staff, and participants involved in product testing. Appreciation is also extended to the faculty for providing facilities and guidance that contributed to the successful completion of this study on lemongrass-based aromatherapy balm for muscle pain relief and body relaxation.

Conflict of Interest

There are no potential conflicts of interest relevant to this article.

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