

Effect of essential oils on pain management: what do we know and where do we go?

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Abstract: Pain is a complex and subjective experience that affects the quality of life and well-being of individuals. Conventional pharmacological treatments for pain have limitations and adverse effects, such as addiction, tolerance, and organ damage. Therefore, alternative, and complementary therapies, such as essential oils, are needed. Essential oils are volatile and aromatic compounds extracted from plants, which have been used for centuries in traditional medicine and aromatherapy for pain relief. Essential oils can modulate the activity of pain receptors, neurotransmitters, inflammatory mediators, and immune cells, as well as influence the psychological and emotional aspects of pain. However, the evidence on the effect of essential oils on pain management is still limited and inconsistent, due to the heterogeneity of the methods, the variability of the essential oil composition and quality, and the lack of standardized outcome measures and rigorous clinical trials. More research is needed to establish the efficacy, safety, and optimal dosage of essential oils for pain management, as well as to elucidate the underlying mechanisms and the potential interactions with other treatments. This article reviews the current state of knowledge on the effect of essential oils on pain management and identifies the gaps and challenges for future research.

Keywords: Essential Oils; Pain; Critical Review.

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1. Introduction

Pain is a complex and subjective experience that involves sensory, emotional, cognitive, and behavioral components. Pain can be acute or chronic, and it can affect the quality of life and well-being of individuals. Pain management is a multidisciplinary approach that aims to reduce pain intensity, improve function, and enhance coping skills. However, conventional pharmacological treatments for pain, such as opioids and nonsteroidal anti-inflammatory drugs (NSAIDs), have limitations and adverse effects, such as addiction, tolerance, gastrointestinal bleeding, and renal damage. Therefore, there is a need for alternative and complementary therapies that can provide safe and effective pain relief [1].

Essential oils are volatile and aromatic compounds extracted from plants, which have been used for centuries in traditional medicine and aromatherapy for various purposes, including pain relief. Essential oils can be applied topically, inhaled, or ingested, and they can exert their effects through different mechanisms, such as modulating the activity of pain receptors, neurotransmitters, inflammatory mediators, and immune cells. Essential oils can also influence the psychological and emotional aspects of pain, such as mood, anxiety, stress, and sleep quality [1, 2].

Several studies have investigated the effect of essential oils on different types of pain, such as headache, menstrual pain, musculoskeletal pain, neuropathic pain, and cancer pain. However, the evidence is still limited and inconsistent, due to the heterogeneity of

the methods, the variability of the essential oil composition and quality, and the lack of standardized outcome measures and rigorous clinical trials. Therefore, more research is needed to establish the efficacy, safety, and optimal dosage of essential oils for pain management, as well as to elucidate the underlying mechanisms and the potential interactions with other treatments [2].

This article aims to review the current state of knowledge on the effect of essential oils on pain management, and to identify the gaps and challenges for future research.

2. Essential oils: their chemical composition, extraction methods, and modes of administration

Essential oils are natural products that have a wide range of applications and benefits. They are defined as volatile, odoriferous, and often bioactive substances that are extracted from various parts of plants, such as flowers, leaves, bark, roots, seeds, or peel. Essential oils are also known as volatile oils, ethereal oils, aetheroleum, or simply as the oil of the plant from which they were extracted, such as oil of clove. Essential oils can be classified according to different criteria, such as their botanical origin, their chemical composition, their functional groups, their odor characteristics, or their therapeutic properties. For example, based on their chemical composition, essential oils can be divided into two major groups: terpenoids and phenylpropanoids³. Terpenoids are derived from the isoprene unit and include monoterpenes, sesquiterpenes, diterpenes, and triterpenes. Phenylpropanoids are derived from the shikimate pathway and include phenylpropenes, coumarins, and lignans. These two groups of compounds are responsible for most of the biological activities of essential oils, such as antimicrobial, anti-inflammatory, antioxidant, analgesic, and antispasmodic effects [4].

Essential oils can be extracted from plant materials by various methods, such as distillation, expression, solvent extraction, supercritical fluid extraction, or microwave-assisted extraction³⁴. Distillation is the most common and traditional method, which involves passing steam through the plant material and condensing the vapor to obtain the essential oil¹. Expression is a mechanical method that is mainly used for citrus fruits, which involves squeezing or pressing the peel to release the oil¹. Solvent extraction is a method that uses organic solvents, such as hexane, ethanol, or methanol, to dissolve the essential oil from the plant material. Supercritical fluid extraction is a method that uses a fluid, such as carbon dioxide, at high pressure and temperature to extract the essential oil from the plant material. Microwave-assisted extraction is a method that uses microwave radiation to heat and rupture the plant cells and release the essential oil [5].

Essential oils can be administered by various routes, such as inhalation, topical application, oral ingestion, or rectal or vaginal suppositories⁴. Inhalation is the most common and preferred route, which involves breathing in the vapors of the essential oil from a diffuser, a spray, a steam bath, or a tissue. Topical application is another common route, which involves applying the essential oil diluted in a carrier oil, such as almond or jojoba oil, to the skin, the hair, or the nails. Oral ingestion is a less common and riskier route, which involves swallowing the essential oil in a capsule, a tablet, a drop, or a honey spoon [5, 6].

Rectal or vaginal suppositories are rare and controversial routes, which involve inserting the essential oil in a solid or semi-solid form into the rectum or the vagina. Essential oils are complex and diverse natural products that have multiple applications and benefits in pain control. They are obtained from various parts of plants by different extraction methods and can be administered by various routes. They have different chemical compositions and classifications that determine their biological activities and therapeutic properties [6].

3. Mechanisms of action of essential oils on pain and inflammation

The mechanisms of action of essential oils on pain and inflammation are complex and multifactorial, involving different pathways and systems in the body. Essential oils can modulate the nervous system by affecting the peripheral and central nervous system, influencing the transmission and perception of pain signals. They interact with various receptors, channels, and neurotransmitters, such as opioid, cannabinoid, TRP, sodium, potassium, calcium, glutamate, GABA, serotonin, and dopamine. For instance, lavender, chamomile, and rosemary essential oils can activate the opioid system, producing analgesic effects, while peppermint, eucalyptus, and clove oils can modulate TRP channels involved in nociception and thermosensation. Bergamot, lemon, and orange oils can influence serotonin and dopamine levels, related to mood and pain modulation [7].

Essential oils also regulate the immune system, affecting the inflammatory response mediated by the immune system. They modulate the production and release of pro-inflammatory and anti-inflammatory cytokines, such as $\text{TNF-}\alpha$, IL-1 β , IL-6, IL-10, and IL-4. Thyme, oregano, and tea tree essential oils can inhibit the expression of $\text{TNF-}\alpha$ and IL-1 β , involved in acute and chronic inflammation, while frankincense, myrrh, and sandalwood oils stimulate the production of IL-10 and IL-4, involved in anti-inflammatory and immunoregulatory processes [8].

Furthermore, essential oils alter the endocrine system, influencing the hormonal balance controlled by the endocrine system. They can affect the secretion and activity of hormones like cortisol, adrenaline, noradrenaline, melatonin, and endorphins. Lavender, ylang-ylang, and jasmine oils can reduce cortisol, adrenaline, and noradrenaline levels involved in stress and pain response, while clary sage, geranium, and rose oils can increase melatonin and endorphin levels, related to sleep and pain relief [7].

These mechanisms represent some of the main ways essential oils act on pain and inflammation, yet ongoing research continues to uncover additional mechanisms. Essential oils exhibit diverse biological activities and therapeutic properties beneficial for pain management. However, further studies are necessary to fully understand the precise mechanisms, doses, routes, and combinations of essential oils for various types of pain and inflammation [7, 8].

3. Mechanisms of action of essential oils on pain and inflammation

Pain is a complex and subjective experience that can be caused by various factors and conditions. Depending on the type and source of pain, different essential oils may be more or less effective in providing relief. Some of the common types and sources of pain that can be treated with essential oils are:

- **Nociceptive pain:** This is the pain that results from tissue damage or inflammation, such as cuts, burns, bruises, sprains, or arthritis. It is usually throbbing, aching, or sharp, and can be localized or widespread¹. Some of the essential oils that can help with nociceptive pain are lavender, rose, bergamot, wintergreen, peppermint, rosemary, eucalyptus, chamomile, clary sage, ginger, clove, lemongrass, and frankincense²³⁴. These oils can reduce inflammation, swelling, spasms, and sensitivity, as well as provide analgesic, antiseptic, and soothing effects.
- **Neuropathic pain:** This is the pain that results from nerve damage or dysfunction, such as diabetes, shingles, sciatica, or multiple sclerosis. It is usually burning, tingling, shooting, or numb, and can be difficult to treat with conventional painkillers¹. Some of the essential oils that can help with neuropathic pain are lavender, bergamot, wintergreen, peppermint, rosemary, eucalyptus, chamomile, clary sage, ginger, clove, lemongrass, and frankincense. These oils can modulate the nervous system, stimulate blood circulation, regenerate nerve cells, and balance neurotransmitters.
- **Acute pain:** This is the pain that occurs suddenly and lasts for a short time, usually less than six months. It is often a sign of an injury, infection, or illness, and serves as a warning to seek medical attention¹. Some of the essential oils that can help with

acute pain are lavender, rose, bergamot, wintergreen, peppermint, rosemary, eucalyptus, chamomile, clary sage, ginger, clove, lemongrass, and frankincense. These oils can provide immediate relief, reduce inflammation, prevent infection, and promote healing.

- **Chronic pain:** This is the pain that persists for a long time, usually more than six months. It can be caused by an underlying condition, such as arthritis, fibromyalgia, or cancer, or by unknown factors. It can affect the quality of life, mood, and sleep of the sufferer¹. Some of the essential oils that can help with chronic pain are lavender, rose, bergamot, wintergreen, peppermint, rosemary, eucalyptus, chamomile, clary sage, ginger, clove, lemongrass, and frankincense. These oils can provide long-term relief, reduce inflammation, improve mood, and enhance sleep.

Essential oils can be used in various ways, such as inhalation, topical application, massage, bath, or compress, depending on the preference and condition of the user. However, essential oils should always be used with caution, as they can cause allergic reactions, skin irritation, or drug interactions [2, 9].

4. The evidence of the efficacy and safety of essential oils in pain management

The evidence of the efficacy and safety of essential oils in pain management is a topic that has been investigated by various studies, ranging from systematic reviews and meta-analyses to randomized controlled trials and animal studies. However, the results are not consistent and conclusive, as different essential oils, doses, routes, methods, populations, and outcomes have been used and measured. Therefore, more high-quality and standardized research is needed to establish the validity and reliability of essential oils as a complementary therapy for pain relief. Here are some of the main findings from the existing literature [1, 2].

A systematic review and meta-analysis of preclinical evidence¹ evaluated the efficacy of essential oils in reducing acute nociceptive and neuropathic pain in animal models. The review included 127 studies, involving 29 different essential oils and 16 pain models. The results showed that essential oils had a significant analgesic effect in both types of pain, with a mean effect size of -1.07 for acute nociceptive pain and -1.22 for neuropathic pain. The most effective essential oils were lavender, eucalyptus, peppermint, rosemary, and clove. The review also assessed the quality of the studies and found that most of them had a high risk of bias and low reporting quality, which limited the generalizability and applicability of the findings [1].

A protocol for a systematic review and meta-analysis² aims to examine the effectiveness of aromatherapy in preventing and/or treating injury, disease, medical conditions, or preclinical conditions. The review will include randomized trials comparing aromatherapy to no aromatherapy, massage alone, or 'gold standard' treatments, for any condition, pre-condition, injury, or risk factor. The outcomes will be based on broad categories, such as pain, emotional functioning, sleep disruption, and adverse events. The review will also use GRADE methods to assess the certainty of evidence and summarize the findings [2].

A web article from Johns Hopkins Medicine provides an overview of aromatherapy and its potential benefits and risks. The article states that some studies indicate that aromatherapy can help with stress, anxiety, depression, insomnia, nausea, pain, and infections, while others show no improvement in symptoms. The article also warns that aromatherapy is not regulated by the Food and Drug Administration (FDA) and that some essential oils can cause allergic reactions, skin irritation, or drug interactions. The article advises to consult a healthcare provider before using aromatherapy and to use it with caution and moderation [10].

A research article⁴ evaluated the efficacy of 30 different essential oils against biofilm-forming bacteria that cause chronic wounds and infections. The study used a microdilution method to determine the minimum inhibitory concentration (MIC) and minimum biofilm eradication concentration (MBEC) of each essential oil against six bacterial strains.

The results showed that the most effective essential oils were oregano, thyme, cinnamon, clove, and tea tree, which had the lowest MIC and MBEC values. The study also tested the cytotoxicity of the essential oils on human fibroblasts and keratinocytes and found that the most cytotoxic oils were oregano, thyme, cinnamon, and clove, while the least cytotoxic oils were lavender, chamomile, and rose. The study suggested that essential oils could be used as alternative or adjuvant therapies for chronic wound infections, but their safety and efficacy should be further investigated in clinical trials [10].

Therefore, the effectiveness and safety of essential oils in pain management remain inconclusive, with varied findings in existing literature. While preclinical studies suggest analgesic effects, the lack of standardized research calls for further investigation to establish the validity of essential oils as a complementary therapy for pain relief. Caution is advised, as ongoing studies emphasize potential risks and advise consulting healthcare providers due to the lack of FDA regulation and the possible adverse effects of certain essential oils. Additionally, research on essential oils against bacteria indicates potential applications in chronic wound infections, urging further exploration in clinical trials to determine safety and efficacy.

5. The advantages and disadvantages of essential oils compared to conventional analgesics

Essential oils are natural products that have been used for centuries for various purposes, such as aromatherapy, cosmetics, perfumery, and medicine. Compared to conventional analgesics, such as opioids, nonsteroidal anti-inflammatory drugs (NSAIDs), and antidepressants, essential oils have some advantages and disadvantages that should be considered before using them for pain management. Essential oils offer a broad spectrum of biological activities and therapeutic properties, proving beneficial for diverse pain and inflammation types, including nociceptive, neuropathic, acute, and chronic pain. Their capacity to modulate the nervous, immune, and endocrine systems influences pain signal transmission, inflammatory responses, and hormonal balance. Notably, essential oils provide both immediate and long-term relief, reduce inflammation, enhance mood, and improve sleep. The versatility of their application methods, such as inhalation, topical use, massage, bath, or compress, allows customization based on user preference and condition [1, 11].

In comparison to common pain management alternatives, essential oils present advantages. They exhibit fewer side effects and carry a lower risk of addiction, tolerance, and withdrawal compared to opioids often prescribed for severe pain. Essential oils also pose fewer gastrointestinal and cardiovascular complications than NSAIDs, commonly used for mild to moderate pain and inflammation. Moreover, essential oils demonstrate fewer interactions and contraindications than antidepressants, occasionally prescribed for neuropathic and chronic pain. Despite their potential benefits, essential oils come with several disadvantages. Firstly, the lack of regulation by the Food and Drug Administration (FDA) means that the quality, purity, and potency of essential oils can vary based on factors like source, extraction method, and storage conditions. This variability raises concerns about consistency and reliability. Moreover, essential oils may lead to adverse effects, including allergic reactions, skin irritation, or drug interactions, particularly when used improperly, excessively, or without consultation with a healthcare provider. The effects can also vary among individuals based on factors such as dose, route of administration, and the combination of oils used [1, 11].

Another drawback is the potential cost associated with essential oils, particularly for rare, exotic, or organic varieties, making them expensive for some users. This financial aspect may limit accessibility for individuals seeking cost-effective alternatives. Furthermore, the use of essential oils raises environmental and ethical concerns. Issues such as overharvesting, deforestation, and exploitation of workers and animals can be associated with the production of certain essential oils, posing challenges from both ecological and ethical standpoints. Therefore, essential oils can be a useful and natural alternative or

complement to conventional analgesics for pain management, but they should be used with caution and knowledge. More research is needed to establish the optimal use and efficacy of essential oils for different pain conditions and populations [1,2].

6. The potential adverse effects and interactions of essential oils with other medications

Essential oils are natural products that have been used for centuries for various purposes, such as aromatherapy, cosmetics, perfumery, and medicine. However, they are not without potential adverse effects and interactions with other medications, herbs, or supplements [12]. Here are some of the main points to consider before using essential oils for pain management:

- Allergic reactions: Some people may experience irritation or allergic reactions to certain essential oils, especially if they have atopic dermatitis or a history of reactions to topical products. Although you can experience a reaction to any essential oil, some are more likely to cause allergies, such as cinnamon, clove, lemongrass, and ylang-ylang. Symptoms of an allergic reaction may include rash, itching, swelling, redness, or difficulty breathing. To prevent or reduce the risk of an allergic reaction, you should always do a patch test before using an essential oil, dilute the essential oil with a carrier oil, and avoid applying it to sensitive areas, such as the eyes, mouth, or genitals.
- Drug interactions: Some essential oils may interact with other medications, herbs, or supplements, either enhancing or reducing their effects. For example, some essential oils, such as lavender, chamomile, and valerian, may have sedative properties and thus can be dangerous when combined with anesthesia, alcohol, or other drugs that cause drowsiness. Other essential oils, such as rosemary, peppermint, and eucalyptus, may have blood-thinning properties and thus can increase the risk of bleeding when taken with anticoagulants, such as warfarin, aspirin, or clopidogrel. Other essential oils, such as grapefruit, lemon, and bergamot, may affect the metabolism of certain drugs, such as statins, antidepressants, or antihistamines, by inhibiting or inducing the enzymes that break them down in the liver. To avoid or minimize the risk of drug interactions, you should always consult your healthcare provider before using essential oils, especially if you are taking any prescription or over-the-counter medications, herbs, or supplements.
- Side effects: Some essential oils may cause side effects, such as nausea, headache, fatigue, or photosensitivity, if used improperly, excessively, or without caution. For example, some essential oils, such as peppermint, wintergreen, or camphor, may cause nausea or vomiting if ingested. Other essential oils, such as lavender, tea tree, or clary sage, may cause hormonal changes or breast enlargement in some people, especially children or pregnant women. Other essential oils, such as citrus oils, may cause photosensitivity or skin burns if exposed to sunlight or ultraviolet rays. To prevent or reduce the risk of side effects, you should always follow the instructions and recommendations of a trained professional when using essential oils, use them in moderation and for a limited time, and avoid exposure to direct sunlight or heat sources after applying them [12].

Thus, essential oils can be a useful and natural alternative or complement to conventional analgesics for pain management, but they should be used with caution and knowledge. More research is needed to establish the optimal use and efficacy of essential oils for different pain conditions and populations.

6. The recommendations and guidelines for the optimal use of essential oils in pain control

The optimal use of essential oils in pain control depends on various factors, such as the type and source of pain, the individual characteristics and preferences of the user, the quality and purity of the essential oils, and the availability and accessibility of the essential oils. However, some general recommendations and guidelines can be followed to ensure the safety and efficacy of essential oils for pain relief. The dosage of essential oils for pain control varies depending on the route of administration, the potency of the essential oil, and the sensitivity of the user. However, a general rule of thumb is to use at least 6 tea-spoons of carrier oil for every 15 drops of essential oil¹. Carrier oils include coconut oil, olive oil, argan oil, and more. Carrier oils help to dilute the essential oil and prevent skin irritation or allergic reactions. The dosage can be adjusted according to the response and tolerance of the user, but it is advisable to start with a low dose and increase gradually if needed [5].

The duration of essential oils for pain control depends on the type and severity of pain, the frequency of application, and the individual response of the user. However, a general rule of thumb is to use essential oils for a limited time, such as a few days or weeks, and not for a long term, unless under the supervision of a healthcare provider. This is because essential oils can have side effects, such as nausea, headache, fatigue, or photosensitivity, if used improperly, excessively, or without caution. The duration can be adjusted according to the improvement and relief of the pain, but it is advisable to stop using essential oils if the pain persists or worsens. The frequency of essential oils for pain control depends on the type and intensity of pain, the mode of application, and the individual needs of the user. However, a general rule of thumb is to use essential oils once or twice a day, or as needed, for acute or mild pain, and three or four times a day, or as directed, for chronic or severe pain. The frequency can be adjusted according to the effect and comfort of the user, but it is advisable to avoid overusing or underusing essential oils for pain relief [13].

The route of essential oils for pain control depends on the location and nature of pain, the preference and convenience of the user, and the characteristics and properties of the essential oil. However, some common routes are inhalation, topical application, oral ingestion, or rectal or vaginal suppositories. Inhalation is the most common and preferred route, which involves breathing in the vapors of the essential oil from a diffuser, a spray, a steam bath, or a tissue. Topical application is another common route, which involves applying the essential oil diluted in a carrier oil, such as almond or jojoba oil, to the skin, the hair, or the nails. Oral ingestion is a less common and riskier route, which involves swallowing the essential oil in a capsule, a tablet, a drop, or a honey spoon³. Rectal or vaginal suppositories are rare and controversial routes, which involve inserting the essential oil in a solid or semi-solid form into the rectum or the vagina [14].

Finally, the combination of essential oils for pain control depends on the synergy and compatibility of the essential oils, the desired outcome and effect, and the personal taste and experience of the user. However, some general guidelines are to use essential oils that have similar or complementary properties, such as anti-inflammatory, analgesic, or sedative, to enhance their effectiveness and reduce their side effects. Some examples of effective combinations are lavender and chamomile, peppermint and eucalyptus, rosemary and ginger, or frankincense and myrrh. The combination can be customized according to the preference and response of the user, but it is advisable to test the combination before using it and to avoid mixing too many essential oils at once [12-14].

4. Conclusion

In summary, essential oils are volatile organic compounds derived from plants that have various biological activities and therapeutic properties. They can be classified into different groups based on their chemical composition, extraction methods, and modes of

administration. Essential oils can modulate pain and inflammation by interacting with the nervous system, the immune system, and the endocrine system. They can affect the perception, transmission, and modulation of pain signals, as well as the production and release of inflammatory mediators. Essential oils can be used to treat different types and sources of pain, such as nociceptive, inflammatory, neuropathic, acute, and chronic pain. The evidence of the efficacy and safety of essential oils in pain management is growing, based on systematic reviews, meta-analyses, randomized controlled trials, and animal studies.

Essential oils have some advantages over conventional analgesics, such as opioids, nonsteroidal anti-inflammatory drugs, and antidepressants. They can offer a natural, holistic, and personalized approach to pain control, with fewer side effects and lower risk of addiction, tolerance, and dependence. However, essential oils also have some disadvantages, such as variability, inconsistency, and lack of standardization in their quality, purity, and potency. Essential oils can also cause potential adverse effects and interactions with other medications, herbs, or supplements, such as skin irritation, allergic reactions, photosensitivity, cytotoxicity, hepatotoxicity, and drug potentiation or inhibition.

Therefore, essential oils should be used with caution and under the guidance of a qualified health professional. The optimal use of essential oils in pain control depends on several factors, such as the type and source of pain, the individual characteristics and preferences of the patient, the chemical composition and therapeutic properties of the essential oil, and the dosage, duration, frequency, route, and combination of administration. More research is needed to establish the best practices and protocols for the use of essential oils in pain management, as well as to elucidate the mechanisms of action and pharmacokinetics of essential oils in the human body. Essential oils are promising natural agents that can complement or substitute conventional analgesics in the treatment of pain and inflammation.

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