Mini-Review

The Therapeutic Potential of Essential Oils in Cancer Treatment: A Comprehensive Review

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Abstract: Essential oils, known for their complex mixture of bioactive compounds, have long been used in traditional medicine and have shown potential in treating various diseases, including cancer. Recent studies highlight their anticancer properties, such as cytotoxic, antiproliferative, and antimetastatic effects. Essential oils contain molecules like terpenes and phenylpropanoids, which induce apoptosis in cancer cells by interfering with cellular signaling pathways. For instance, frankincense oil induces programmed cell death in breast cancer cells, while compounds like curcumin and thymol inhibit the proliferation of colorectal cancer cells. Additionally, certain essential oils prevent metastasis by inhibiting the migration and invasion of cancer cells. Despite promising preclinical results, the effectiveness and safety of essential oils in cancer treatment require further validation through human clinical trials. This review discusses the potential of essential oils as complementary therapies in cancer treatment, emphasizing the need for cautious application under professional supervision due to their concentrated nature and possible adverse effects. The therapeutic promise of essential oils lies in their ability to induce apoptosis, inhibit cell proliferation, and prevent metastasis, underscoring the importance of rigorous research to ensure their safe and effective use in oncology.

Keywords: Essential oils, Cancer treatment, Anticancer properties.

1. Introduction

Essential oils, also known as volatile oils, are aromatic liquids extracted from various parts of plants. They have been used in traditional medicine for centuries, dating back to the first text of Chinese Traditional Medicine, The Divine Farmer’s Materia Medica1. These oils contain components in exact proportions that contribute synergistically to the whole plant effect, representing a form of combinatorial medicine [1]. Essential oils are natural odorous products made up of a complex mixture of low molecular weight compounds with recognized biological and pharmacological properties [2]. They have been investigated for the prevention and treatment of various diseases, including cancer [2].

Cancer is one of the leading causes of death worldwide, affecting millions of people each year. According to the Global Cancer Statistics 2020, an estimated 19.3 million new cancer cases and almost 10.0 million cancer deaths occurred in 2020. Female breast cancer has surpassed lung cancer as the most diagnosed cancer, with an estimated 2.3 million new cases (11.7%), followed by lung (11.4%), colorectal (10.0%), prostate (7.3%), and stomach (5.6%) cancers [3]. The burden of cancer incidence and mortality is rapidly growing worldwide; this reflects both aging and growth of the population as well as changes in the prevalence and distribution of the main risk factors for cancer, several of which are associated with socioeconomic development [3].
Despite significant advances in conventional cancer treatments, such as surgery, radiation, chemotherapy, and targeted therapies, cancer remains a major global health problem. The side effects of these treatments, their high cost, and the increasing incidence of drug resistance have led many patients to seek alternative therapies [4]. Complementary and alternative medicine (CAM) refers to a wide range of practices and therapies outside the realm of conventional medicine, which are used to prevent and treat illness, manage symptoms, improve quality of life, or promote well-being [5]. Among CAM therapies, the use of essential oils has gained popularity in recent years due to their potential therapeutic properties [5].

Research has shown that essential oils and their constituents have potent anticancer activities, both in vitro and in vivo [6]. For instance, a study published in the Journal of the National Cancer Institute found that patients with nonmetastatic breast, prostate, lung, or colorectal cancer who chose essential oils as their sole anticancer treatment had a greater risk of death compared with those who received conventional cancer treatment [4]. This suggests that while essential oils may have potential as complementary therapies, they should not replace conventional treatments. Further research is needed to better understand the mechanisms of action of essential oils and their bioactive compounds, as well as their effectiveness and safety in use6.

Therefore, essential oils, with their long history of use in traditional medicine, have shown potential in the treatment of various diseases, including cancer. However, while they may offer some benefits as complementary therapies, they should not replace conventional cancer treatments. As the prevalence of cancer continues to rise globally, there is an increasing need for effective and affordable treatments. This mini-review aims to explore the current research on the use of essential oils in cancer treatment, highlighting both their potential benefits and the need for further research to ensure their safe and effective use.

2. Efficacy of Essential Oils in Relieving Cancer Pain

Essential oils have been used for centuries in traditional medicine for their therapeutic properties. Recently, their potential efficacy in relieving cancer pain has gained scientific interest. A systematic review and meta-analysis conducted by Corasaniti et al. provides significant evidence supporting the use of essential oils in reducing the intensity of pain associated with cancer [7]. This study aimed to appraise the efficacy of aromatherapy in cancer pain in clinical studies with different designs. The search retrieved 1002 total records, out of which twelve studies were included and six were eligible for meta-analysis. The results of the meta-analysis demonstrated significant efficacy of the use of essential oils in reducing the intensity of pain associated with cancer. This finding is crucial as over 80% of patients affected by cancer develop cancer-related pain, one of the most feared consequences because of its intractable nature, particularly in the terminal stage of the disease. However, the study also highlighted the need for earlier, more homogeneous, and appropriately designed clinical trials. This is important to ensure the effective and safe management of cancer-related pain using essential oils and to provide a rational basis for their clinical use in integrative oncology [7].

The study of Scuteri et al. [8] examines the analgesic properties of various essential oils through preclinical studies. The review highlights that while certain essential oils, such as bergamot, show promise in reducing pain, the overall evidence remains inconclusive due to methodological inconsistencies across studies. It calls for more rigorous and standardized research to establish the potential clinical applications of essential oils in pain management. Additionally, the study by Xie et al. [9] investigates the effects of aromatherapy on cancer patients undergoing radiotherapy and chemotherapy. Through a meta-analysis of 19 studies with 1,541 patients, it was found that aromatherapy can significantly alleviate nausea, vomiting, sleep disorders, pain, and fatigue, and improve the quality of life. However, it may not significantly reduce anxiety. The studies reviewed had
a high risk of bias, and no studies were deemed high quality by GRADE standards. More rigorous research is needed to confirm these findings.

Here, we can see that the therapeutic use of essential oils, historically rooted in traditional medicine, has shown potential in alleviating cancer-related pain, as evidenced by recent systematic reviews and meta-analyses. While studies demonstrate significant benefits in reducing pain, nausea, vomiting, sleep disorders, and improving quality of life [8, 9], the overall evidence remains inconclusive due to methodological inconsistencies. So, rigorous and standardized clinical trials are necessary to validate these findings and ensure the safe integration of essential oils into oncology care.

3. Anti-Breast Cancer Activity of Essential Oils

Breast cancer is the second highest cancer-related death worldwide. The conventional treatment for breast cancer is chemotherapy; however, occurrences of multidrug resistance, unselective targets, and physicochemical problems suggest that chemotherapy treatment is often ineffective. Therefore, there is a need to find better alternatives. Essential oils, which are plant secondary metabolites, have shown promising bioactivities and pharmacological effects, including anti-breast cancer capabilities [10].

A systematic review by Mustapa et al. discusses and summarizes the effect of essential oils on anti-breast cancer. The review reveals that the compositions of essential oils, mainly terpenoids, have excellent anti-breast cancer pharmacological effects. Terpenoids are a large and diverse class of naturally occurring organic chemicals derived from five-carbon isoprene units assembled and modified in thousands of ways. They are a major component of resin and turpentine produced by coniferous trees [10].

The review found that essential oils have an IC50 value of 0.195 μg/mL. The IC50 value is a measure of the effectiveness of a substance in inhibiting a specific biological or biochemical function. This IC50 value indicates the concentration of the substance needed to inhibit a biological process by half, thus providing a measure of the substance's potency. Hence, essential oils have potential as anti-breast cancer drug candidates with the highest efficacy and the fewest side effects. This is a significant finding, as it suggests that essential oils could be a viable alternative or complementary treatment for breast cancer, offering hope for patients who have not responded well to conventional treatments [10].

The study of Nagata et al. [11] investigates the antitumor effects of essential oils on breast cancer cells. The study found that the essential oils of lemongrass, lemon myrtle, litsea, and melissa, particularly due to their high citral content, effectively inhibit the growth and invasion of breast cancer cells. Citral, especially, showed strong antiproliferative and anti-invasion effects on these cells, indicating its potential as a complementary treatment in cancer therapy. Additionally, Khan and colleagues [12] discuss breast cancer, a leading cause of death among women, and emphasizes the need for novel therapeutic drugs targeting various checkpoints. Natural products like plant-derived compounds, including flavonoids, terpenoids, phenolic acids, and alkaloids, have shown significant anti-breast cancer properties. These compounds exert cytotoxic activities through mechanisms such as apoptosis inhibition, cell cycle arrest, and autophagy activation. They also exhibit anti-angiogenesis and antimetastatic actions. The review highlights the pharmacological actions of medicinal plants and their bioactive compounds on breast cancer and their role in chemoprevention. However, while these findings are promising, more research is needed to confirm the anti-breast cancer activity of essential oils and to understand their mechanisms of action. Future studies should also evaluate the safety and efficacy of essential oils in clinical settings.

4. Anticancer mechanisms in other types of cancer: what do we know?

Essential oils have been the subject of numerous studies due to their anticancer properties, demonstrating cytotoxic, antiproliferative, and antimetastatic effects on cancer cells. These studies indicate that bioactive compounds present in essential oils may be
potential therapeutic agents against various types of cancer. Here, we will comprehensively discuss these properties and the mechanisms involved, based on recent studies.

Firstly, it is important to understand that essential oils are complex mixtures of volatile compounds extracted from plants. They contain a variety of bioactive molecules, such as terpenes and phenylpropanoids, which have shown significant potential in preclinical studies. According to conducted studies, many essential oils exhibit cytotoxic effects against cancer cells, meaning they can directly kill these cells. For example, frankincense essential oil has been shown to induce apoptosis, or programmed cell death, in breast cancer cells by interfering with the cellular signaling pathways that promote the growth and survival of cancer cells [12, 13].

In addition to cytotoxic effects, essential oils also demonstrate antiproliferative properties, which inhibit the ability of cancer cells to multiply. Studies on colorectal cancer cells have revealed that compounds present in essential oils such as curcumin and thymol can significantly inhibit the proliferation of these cells. This effect is crucial because uncontrolled proliferation is a hallmark of cancer. These compounds seem to act through the modulation of specific molecular pathways, such as the adenosine monophosphate-activated protein kinase (AMPK) pathway and the mammalian target of rapamycin (mTOR) pathway, which are crucial for controlling cell growth and proliferation [12].

The antimetastatic effects of essential oils are also of great interest. Metastasis, the spread of cancer to other parts of the body, is the leading cause of cancer-associated mortality. Studies indicate that certain essential oils can inhibit the migration and invasion of cancer cells, fundamental processes for metastasis. For instance, lavender essential oil has been shown to inhibit the ability of breast cancer cells to migrate and invade adjacent tissues, suggesting its potential to prevent cancer spread [13].

It is evident that there is a wide range of bioactive effects of essential oils in experimental models of colorectal cancer. Results have shown that essential oils can modulate the expression of genes and proteins involved in apoptosis, cell cycle, and oxidative stress response, providing a molecular basis for their anticancer effects. For example, Cymbopogon citratus (lemongrass) essential oil has been demonstrated to cause cell viability loss and activate the apoptotic process in colorectal cancer cells [12-13]. Additionally, concerning breast cancer treatment with essential oils, it is reported that compounds such as α-pinene, present in pine essential oil, and geraniol, in geranium essential oil, can activate signaling pathways that suppress the viability and proliferation of cancer cells, as well as inhibit cell migration and invasion. These findings are particularly promising as they suggest that essential oils can be used as adjuvants to enhance the effects of conventional therapies [13].

While the results are promising, it is essential to approach these findings with caution. Most studies to date have been conducted in vitro or in animal models, and there is a critical need for human clinical trials to confirm the efficacy and safety of essential oils as anticancer treatments. Additionally, it is important to remember that essential oils are highly concentrated and can cause adverse effects if used improperly. Therefore, any therapeutic use should be supervised by qualified healthcare professionals. Here, it is envisioned that essential oils present significant potential as therapeutic agents in cancer treatment, with studies demonstrating a variety of beneficial effects, including inducing apoptosis, inhibiting cell proliferation, and preventing metastasis. However, it is crucial that additional research, especially human clinical trials, be conducted to validate these effects and ensure the safety and efficacy of these compounds in a clinical context.

5. Conclusion

The narrative review presented demonstrates the potential of Citrus aurantium essential oil, commonly known as bitter orange, in the treatment of anxiety. Through a comprehensive analysis of the existing literature, it is observed that Citrus aurantium essential oil has anxiolytic, antidepressant, and sedative properties attributed to its interaction with the serotonergic and GABAergic neurotransmitter systems. Studies in both animal models
and clinical contexts suggest a significant reduction in behaviors associated with anxiety, standing out as a promising alternative for the management of preoperative anxiety and other stressful conditions.

The safety of using this essential oil is considered acceptable in appropriate doses and for short periods, although adverse effects such as skin irritation, photosensitivity, and potential drug interactions have been reported. However, the review also highlights the methodological variability of the studies and the need for more research to conclusively establish the efficacy and safety of using *Citrus aurantium* essential oil in different populations and contexts. Therefore, while *Citrus aurantium* essential oil offers a promising alternative for the treatment of anxiety, it is imperative that future research be directed at elucidating optimal dosages, routes of administration, duration of treatment, and possible side effects. This will ensure a safe and effective application of this therapeutic approach. Additionally, it is recommended that the use of *Citrus aurantium* be accompanied by medical guidance, especially for individuals with pre-existing health conditions or who are taking medications that may interact with its components. In short, *Citrus aurantium* essential oil stands out as a valuable candidate in the spectrum of complementary treatments for anxiety, although its implementation should be cautious and based on robust evidence.

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**References**


