Chapter 01

Essential Oils: Potential Therapeutic Compounds for One Health

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ABSTRACT

Essential oils are volatile fragrant chemicals that can be acquired from natural plants in different ways. They can be obtained from roots, flowers, stems, leaves, seeds, and gums. Many plants are used for this purpose nowadays, like cinnamon, mint, lavender, etc. All these plants have different chemical procedures to extract their oils in the laboratory. Many old and emergent methods have been used nowadays. The most common methods are steam distillation, cold pressing, solvent extraction, superfluid extraction, ultra-sound, and microwave-assisted extraction. Known till now, the microwave-assisted extraction method is recognized as the optimal method for extracting premium quality oils. All above listed essential oils have great potential to resolve medical issues like neurodegenerative disease, cancer, cardiovascular disease, gut related issues. These oils also have a vast power to treat illness and have antimicrobial and antibiotic properties. Moreover, these oils are commercially used as Nano-medicine particles that guarantee their regular distributions and solubility in water. The extraction of essential oils and their application in the medical field constitute a significant human discovery.

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INTRODUCTION

The volatile aromatic liquids known as essential oils (E0s) are derived from natural plants. According to Soliman et al. (2022), the plant components that are gathered encompass their roots, bark, wood, flowers, leaves, seeds, peels, branches, gums, and oily resin. Secondary metabolites are a collection of compounds that aid plants in controlling their growth and facilitating communication with other plants and species. The complex makeup of essential oil (EO) mostly consists of alcohol, ester, aldehydes, oxides, which are phenols, the coumarins ether and various other constituents (Camele et al., 2021). Essential oils (EOs) are widely utilized in an extensive range of goods for purposes including anti-parasitic, fungicidal, cosmetic, sterilizing, and destroying viruses. Essential oils (EOs), such as lavender, rose, and peppermint oils, are frequently used in the cosmetics sector because of their pleasant scent (Sharmeen, et al., 2021).

Given their pharmacological and psychological properties, essential oils (EOs) have a long history of use and recognition as therapeutic agents. To the indigenous people, they had magical powers that could cure physical, emotional, and spiritual ailments (Ayaz et al., 2017; Lizarraga-Valderrama). Analgesic, neuroprotective, antidepressant, anxiolytic, and sedative effects are just a few of the many CNS-targeted pharmacological effects that EOs have been shown to have in animal and human studies. Dementia, sleeplessness, depressive disorders, dementia, Alzheimer's disease (AD), and other CNS-based disorders can be alleviated or stopped with the use of EOs as an adjuvant treatment. The fact that they occur naturally means that they are also safe and non-toxic in the correct doses, as studies done in the last decade have shown (Lizarraga-Valderrama, 2021).

Chemical Composition of EOs

Essential oils are volatile organic composites that are complex combinations of several compounds, often exceeding 500 in number. Linalool and camphene are two of the many chemicals found in essential oils extracted from plants.

Particular essential oils contain compounds like camphor and menthol. One of the most popular essential oils, lavender, contains eucalyptus, linalool acetate, linalool, and perillyl alcohol among its primary components. Sesquiterpenes, flavonoids, lacton, myrrh alcohol, famesene, tea matzolin, genistein, and volatile oil are present in both varieties of chamomile. Peppermint mostly consists of menthol, menthol acetate, and mentholone. Plant secondary metabolism results in the production of secondary components such as tannins, caffeic acid, 1,8-eucalyptol, propanone, and bitter chemicals. All sorts of plant components, such as blossoms, roots, leaves, bark, seeds, fruit, resins, and so on, produce and contain these compounds. Essential oils derived from various parts of plants also range in their chemical composition. Fragrances, terpenoids, ketones, aldehydes, ethers, epoxy compounds, and other compounds provide the basis for identifying each of these essential oils (Wani et al., 2021). Fig. 1 shows the chemical structures of some Eos.

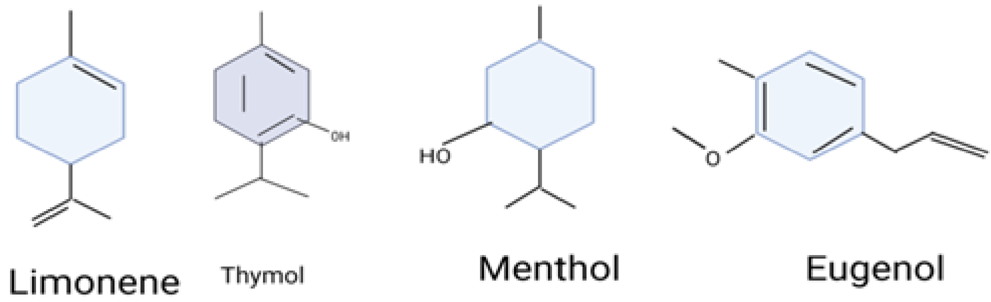

Fig. 1: The Chemical structures of some Eos.

Types of Essential Oils

Peppermint Oil

One of the most common and frequently utilized EOs is peppermint (Mentha piperita) oil. Of the essential oils derived from Menthyl ester and Menthofuran, menthol is the primary constituent (Saharkhiz et al., 2012). Peppermint oil has been shown to have an inhibiting effect on staphylococci growth (Witkowska and Sowińska, 2013).

Melaleuca Alternifolia (Myrtaceae)

Another name for it is Tea Tree Oil, or TTO. Among its components are 1,8-cineole, α-terpinene, γ-terpinene, p-cymene, α-terpinene, γ-terpinen-4-ol, and α-pinene (Pereira et al., 2014). One of its names is Tea Tree Oil, or TTO for short. The clinical investigation found that melaleuca gel inhibited the growth of numerous colonies of bacteria and dental biofilms (Santamaria et al*.,* 2014). Against oral infections, it exhibits potent antibacterial activity (Takarada et al., 2004). The most potent ingredient in Melaleuca alternifolia's antimycotic action is terpinene-4-ol (Terzi et al., 2007)

Lemon EOs

It mostly consists of oxygenated terpenes and terpenes that are nearly exclusive (Trombetta et al., 2005). Therapeutic action shows antifungal potential against three species of Candida: the albicans strain, the tropical Candida species, and *Candida glabrata*. One effective treatment for candidiasis brought on by Candida albicans is lemon essential oil (Trombetta et al., 2005; Białoń et al., 2014).

Cinnamon Oil

The volatile oils derived from various parts of the plant, such as tree bark, foliage, and roots, have very different chemical compositions. Three major constituents comprising 82.5% of the essential oils extracted from the bark of Cinnamomum zeylanicum are trans-cinnamaldehyde, eugenol, and linalool. Studies indicate that the primary and most active ingredient in cinnamon essential oil is cinnamonaldehyde (Naveed et al., 2013).

Inhibition of the growth of several bacterial isolates, including both Gram-positive and Gram-negative strains, as well as fungal isolates (Ooi et al., 2006). It can prevent spontaneous mutations in human cells by acting as an antimutagenic (King et al., 2007). Furthermore, Cabello et al. (2014) found that cinnamaldehyde (CA) had a significant anti-melanoma impact when administered orally. Cinnamomum zeylanicum (CZ) has antiparasitic, antioxidant, and free radical scavenging properties, according to the study (Ramage et al., 2012).

Eucalyptus Oil

It is appropriate for use as an anticariogenic drug since it exhibits a negative y impact on oral bacterian such as *Lactobacillus acidophilus* (Serafino et al., 2008).

Lavender Oil

Linalool, linalyl acetate, 1,8-cineole, B-ocimene, terpinen-4-ol, l-fenchone, camphor, and viridiflorol are the main constituents identified (Benabdelkader et al., 2011; Végh et al., 2012). However, the relative level of each of these constituents varies in different species. Lavender oil is most commonly found in the following compounds: linalyl acetate, linalool, 1,8-cineole, camphor, lavandulyl acetate, and 3,7-dimethylocta-1,6-dien-3-ol, all of which are obtained by distillation with steam from the flowers of the Lamiaceae family plant *Lavandula angustifolia*. Since linalool's effects are felt throughout the oil, it's reasonable to assume that it's the active component of lavender oil (Prashar et al., 2004).

Lavender EO is described to decrease stress, anxiety, and expand mood when inhaled or orally administered (Lehrner et al., 2005; Kim et al., 2011). It is not very effective in cases of high anxiety (Bradley et al., 2009). *Lavandula luisieri* essential oils have an inhibitory effect on strains of Aspergillus, dermatophytes, and yeast (Zuzarte et al., 2012).

Essential Oils Extraction

For use or analysis, Eos needs to be removed from the plant matrix. Many techniques, including popular ones like solvent extraction, steam distillation, hydro-distillation (HD), cold pressing (CP), and simultaneous distillation-extraction techniques, can be applied for this purpose. Even though Eos have been extracted using these methods for many years, numerous disadvantages have been identified by their application, such as the loss of some volatile compounds, less efficiency, the potential for hazardous solvent residues in extracts or EOs, and the breakdown of ester or unsaturated molecules by thermal or hydrolytic processes. As the "Green Era" approaches and energy prices rise, the extraction industries for extraterrestrials (Eos) concentrated on creating emergent extraction techniques (Bousbia et al., 2009). Many novel techniques, due to the shortcomings of conventional extraction techniques, a variety of techniques are currently available for extracting essential oils (Eos) from plants, such as solid-phase micro-extraction, membrane-assisted solvent extraction, pressured liquid extraction, solid-critical fluid extraction (SFE), microwave-assisted and ultrasound-assisted extraction, and others. (Flamini et al., 2007). By using fewer solvents and fossil fuels, producing fewer hazardous substances, and using less energy overall, the environment may be protected and production efficiency increased with these alternatives to conventional extraction techniques (Chemat et al., 2010). Composition and chemical makeup of extra virgin olive oils are greatly influenced by the extraction techniques used (Nakatsu et al., 2000). The most representative traditional and emerging techniques of extracting essential oils (Eos) are provided in the following sections. Give careful thought to the best feasible and suitable technique for concentrating the intended biologically active ingredient into the EO.

Extraction Methods

Primitive Methods of Extraction

Cold Pressing

Cold pressing, sometimes referred to as expression, is the earliest technique for obtaining essential oils; it predates human discovery of the distillation process by many years. Although this method produces low yields, the process produces little to no heat, which is an advantage (Van, 2013). Because the aldehydes in citrus fruit peel oils are rather thermally unstable, it is primarily employed to isolate the oils from the fruit (Kubeczka, 2010). Citrus peels are used in the mechanical cold pressing method, which involves applying pressure or abrasion to rupture the oil glands, causing the oil to be ejected and then cleaned away with a water spray. Because of the shortcomings of this approach, which include low yield extraction and low purity, enzyme pretreatments have been investigated as a means of enhancing the quality and amount of extracted essential oils (Eos). Using a combination of enzymatic hydrolysis and CP, Soto et al. (2007) were able to extract oil from Borage (Borago officinalis) seeds; Collao et al. (2007) was able to enhance the resultant evening elder oil (Oenothera biennis) extraction; and A study conducted by Anwar et al. (2013) examined the impact of several enzyme preparations on the production of cold-pressed flaxseed oil. The results showed that cold-pressed flaxseeds treated with enzymes had a much greater output (38% vs. 32%).

Distillation

Distillation is the conventional process used to extract volatile materials, such as essential oils from plant matter. Fragrant plants that come into touch with steam or boiling water during the distillation process evaporate and release their essential oils. Three different methods of distillation have been suggested: steam distillation, hydrodynamic distillation (HD), and water/steam distillation. The categorization is predicated on how well the water interacts with the initial matrix. The HD technique involves immersing the plant material in boiling water. What differentiates this approach is the direct contact of the raw material with the boiling water. While steam and water are used in steam distillation, the plant material and the water do not come into indirect touch (Mendes et al., 2007).

The plant material is positioned on a tray with holes at the bottom of the container, and steam is forced through a pipe after being produced in a boiler. Water and oil are combined to create the condensed distillate; the oil and water are separated by using a Florentine flask, which does this by using the differences in their densities. The plant material is positioned on a tray with holes at the bottom of the container, and steam is forced through a pipe after being produced in a boiler. Condensed distillate is made by combining water and oil; the oil and water are separated using a Florentine flask, which uses the variations in their densities to do this (Sell, 2006). The material is only ever exposed to steam, never boiling water, and the steam is constantly moist and completely saturated thanks to this process (Hu¨snu and demerici, 2012).

Solvent Extraction

EOs can be extracted using organic solvents, particularly those derived from fuel, due to their hydrophobic and nonpolar properties (Attokaran, 2011). A solute is distributed between two immiscible liquid phases that are in contact with one another; this process is known as solvent extraction (Cox and Rydberg 2004). Using a liquid in which the material is soluble, a substance is transferred from a matrix in this process. Leaching is the process used when the part that can be extracted is a solid, like plant materials. Batch percolation at room temperature is the most straightforward of these procedures. To extract the plant material, it is first ground into a powder and then put into a vertical vessel that has a false bottom. The oil's micelles are kept from passing through by a cloth covering the bottom. Richer extracts are extracted early on and used in the distillation process to create essential oils. The weaker micelle that follows is directed toward the percolator that holds freshly ground plant material. There will be a solute exchange with a weak micelle at this point because the solute concentration is at its highest. Micelles that are progressively weaker and weaker pass through plant material that has been partially extracted. Ultimately, the process is finished when a new solvent is poured through almost all of the extracted material (Attokaran, 2011).

Emergent Methods of EO's Extraction

The chemical, food, and pharmaceutical industries have recently placed a considerable emphasis on developing novel separation processes because of rising energy prices and the need to lessen CO2 emissions (Bousbia et al., 2009). Oil extraction methods being researched include supercritical fluid extraction (SFE), ultrasound-assisted extraction, and microwave-assisted extraction.

Microwave-Assisted Extraction (MAE)

Several Eos have been extracted using microwaves by various researchers in recent years. The results show that Eos extracted in 30 minutes or fewer are qualitatively and quantitatively comparable to those extracted using some traditional techniques, like HD or Soxhlet extraction, that take twice as long (Camel, 2001).

Vacuum microwave HD is one of many methods that have emerged as a result of developments in microwave extraction (Abert-Vian et al., 2011), microwave HD (Golmakani and Rezaei, 2008), solvent extraction and distillation with microwave assistance (Ferhat et al., 2007), solvent-free microwave extraction (Bendahou et al., 2008), microwave accelerated steam distillation (Chemat et al., 2006), and microwave hydro-diffusion and gravity (MHG) (Vian et al., 2008).

In this method, radiations of microwave are used to heat the sample combination. Because of two peculiarities of matter, namely ionic conductance and dipole rotation, microwave heating occurs instantaneously inside the sample, leading to very short extraction times. The breaching of weak hydrogen limits is one benefit of microwave heating. It is different from the extractive procedures used in conventional approaches because electromagnetic waves induce changes in cell structure that result in MAE extraction. Since microwaves automatically reduce the extraction time and solvent amount, they reduce the impact on the environment by expelling less carbon dioxide into the atmosphere (Périno-Issartier et al., 2011).

Ultrasound-Assisted Extraction (UAE)

The phytopharmaceutical extraction industry has acknowledged the potential industrial application of ultrasound for a variety of herbal extracts (Vilkhu et al., 2008). Compared to conventional methods, UAE shortens processing time, reduces solvent volume, and boosts the yield of the extract by employing organic solvents to separate volatile chemicals from natural products at room temp (Alissandrakis et al., 2003). At low frequencies, at 18–40kHz, its effect is substantial; at higher frequencies, between 400 and 800 kHz, it is almost insignificant (Cravotto et al., 2008).

Super-critical Fluid Extraction

Plant components such as essential oils, flavors, and lipids can be extracted with SFE (Wang, 2008); Reverchon (1997) states that SFE has the makings of a profitable industrial technique. When compared to conventional extraction techniques, this emergent method is superior in terms of speed, compound selectivity, and environmental friendliness.

Supercritical fluid extraction (SFE) relies on subjecting solvents to temperatures and pressures higher than their critical points to use them in their supercritical condition. The content, temperature, and pressure of a supercritical fluid (SCF) define its unique properties, which lie between those of a gas and a liquid. These liquids are efficient and selective solvents because they combine the gaseous penetrating ability with the liquid density. The non-toxic nature and ability to achieve supercritical operation at pressures similar to ambient temperature while maintaining relatively low concentrations of carbon dioxide make it the ideal supercritical solvent for chemical extraction from plants (Zizovic et al., 2007).

Extraction of Essential oils from different Plants

Lavender

As everyone is aware, lavender is a fragrant and therapeutic plant that yields a range of plant essential oils used in medicine, food processing, cosmetics, and other sectors (Zhao et al., 2006).

A novel technique was used for obtaining lavender essential oil: steam distillation with microwave assistance. Steam distillation and general microwave-assisted extraction are two methods from the Chinese Pharmacopoeia that were combined to achieve this. Supercritical CO2 extraction experiments have been used to determine the ideal extraction conditions for lavender essential oils, and gas chromatography has been used to assess and evaluate the quality of lavender essential oils extracted using two distinct methods (XI et al., 2002). Furthermore, vacuum distillation has been used to refine lavender essential oil that was obtained through supercritical CO2 extraction. The resulting data serves as a source for the industry of lavender essential oils.

Supercritical CO2 Extraction
Procedure and Conditions

Add powder of lavender to the extraction tank, set the analytical pressure to 6.5MPa and temperature to 45°C, and flow 20 liters per hour of CO_2 into the tank. Extract the lavender powder at a predetermined time after the tank is released from the excerpts of the analysis. Vacuum distillation was used to extract supercritical CO_2 from pressure products after atmospheric distillation, followed by condensation through cold water and an ice-water bath to accept bottles. The temperature was progressively rising to 90°F for distillation after the pressure leveled out at 20mmHg.

Microwave-assisted Steam Distillation

A 500ml round-bottom flask was filled with precisely 25g of lavender powder, 300ml of saturated salt water, and allowed to soak for two hours. Regarding the microwave reactor, two milliliters of petroleum ether were added to the volatile oil extractor. After two hours of microwave heating, adjust the temperature to 105 so that 1-2 drops per second are produced.

Cinnamon (*Cinnamomum zeylanicum)*

According to Chinese texts, *Cinnamomum zeylanicum* is one of the oldest known herbal remedies, with a history that spans four thousand years. Both the leaves and the bark of the cinnamon tree have many medicinal and culinary applications. Steam distillation and Soxhlet extraction were employed to obtain the essential oil.

Steam Distillation Method

According to Chinese texts, *Cinnamomum zeylanicum* is one of the oldest known herbal remedies, with a history that spans four thousand years. Both the leaves and the bark of the cinnamon tree have many medicinal and culinary applications. Steam distillation and Soxhlet extraction were employed to obtain the essential oil.

The essential oils were allowed to volatilize for five to ten hours at 100°C in boiling water. Following a settling period for the recovered mixture, the oil was extracted 9–10. Utilizing a separatory funnel, the product was gathered and separated following the steam distillation process. The essential oils were separated multiple times until there was no more oil in the separatory funnel after they settled into the bottom layer.

Soxhlet Extraction Method

A thimble made from heavy filter paper was filled with 100g of crushed cinnamon sticks, which were then put into the main chamber of the Soxhlet extractor. Ethanol was the extraction solvent used. For five to ten hours, the solvent was brought to a temperature above 100°C for reflux. Following extraction, the products were gathered and refined utilizing a rotating evaporator to maintain a steady temperature of 50°C. After the rotovap process, the samples were placed in a fume hood for an hour to ensure that any remaining ethanol in the crude oil had completely evaporated into the atmosphere.

Basil (Mint)

One popular culinary herb and source of essential oils is Oregano basilicum that is used to flavor food, oral health products, and fragrances. Steam distillation is used to remove essential oils from the leaves and flowering tops of the plant. Next, essential oils were extracted from known weights of stems, flowers, leaves, or an equal portion of both (200g fresh weight and 75g dry weight). The samples were oven-dried for three to seven days at 30°C. The dry weights of the samples in the experiments with varying sample amounts were 75, 20, 15, and 10g. There were three approaches taken.

Hydro-distillation

To extract the essential oil, the plant material was dropped into a 2-liter round-bottomed flask along with 1000ml of distilled, deionized water for every 75g of dry matter and 400ml for every 200g of fresh material. A modified clevenger trap was then used for the water distillation process (ASTA, 1968). Water was added in proportion to the size of the plant samples (13.3ml of water to 1g of dry material). The fresh samples were distilled for one hour, while the dried samples were distilled for one hour and fifteen minutes. The ratio of oil volume to tissue weight was used to determine the essential oil content.

Steam Distillation

The process of steam distillation involved collecting the condensate, which is made up of combining oil and water in a flask and then applying steam for ninety minutes to a 3-liter flask filled with either dried or fresh plant material. To fully extract the essential oil, ethyl ether was used three times to extract the condensate. To eliminate moisture, ethyl ether was mixed with sodium sulfate. Following rotary evaporation for ethyl ether removal, the number of essential oils in the base was calculated by dividing the volume by the weight of the tissue (fresh/dry).

Solvent Extraction

Essential oil was extracted using a solvent using Burbott and Loomis's (1967) method. Ten milliliters of yellow extract were obtained by extracting plant material four times with hexane in a mortar that also contained anhydrous Na2SO4. Each extract received a tiny quantity of Norit Just enough charcoal to remove the yellow pigment—which was subsequently extracted using slow centrifugation. After that, the clear solutions were concentrated at room temperature under an air stream. Samples of essential oils were kept at 2°C in the dark in Teflon-sealed caps contained in silica vials. The stated contents of essential oils are derived from three separate extraction processes.

Mechanism of Action

The chemical makeup and the placement of functional groups on molecules determine the ways of action of essential oils (EOs) (Dorman and Deans, 2000). According to Prashad et al. (2004), the primary mode of action is thought to be damage to the membrane. In terms of their antibacterial action, EOs' solubility in the phospholipid double layer of cell membranes appears to play a significant role. Research has shown that terpenoids present in EOs can disrupt the enzyme processes involved in energy metabolism. Specifically, clove oil has been shown to decrease the amount of ergosterol detected in the cell membranes of fungi (Pinto et al., 2009).

Therapeutic Applications

The volatile constituents of essential oils (EOs) are being widely used to treat and prevent human diseases. The mode of action and significant role of these natural products are discussed regarding the treatment and prevention of many diseases (Edris, 2007). The following are the therapeutic applications of essential oils:

Neurodegenerative Diseases

The potential of Essentials oils (EOs) against neuro-protective and anti-ageing being widely evaluated around the world. Neurodegenerative disorders are frequently characterized by strong evidence of oxidative stress in their pathogenesis, as a result unregulated (ROS) reactive oxygen species formed. Neurodegenerative disorders are mostly incurable, and their therapies only just control symptoms and elongate the growth of disease. Now EOs have been used in the treatment strategies for neurodegenerative and anti-aging disorders (Abd Rashed et al., 2021). An increase in the microglia M1/M2 ratio and a rise in inflammatory processes in the cerebral cortex (inflammation) are both associated with aging and increase the risk of neurodegenerative disorders.

In the post-mortem of an individual, the increase of astrocytes in neural tissue has also been reported. The distinguishing feature of neurodegenerative disease is the accumulation of proteins within neurons and in the extracellular space. (Avola et al., 2024). Huntington's disease (HD), Alzheimer's disease (AD), amyotrophic lateral sclerosis (ALS), and Parkinson's disease (PD) are the four age-related neurodegenerative illnesses that are most frequently researched. Huntington's disease (HD), Parkinson's disease (PD), Alzheimer's disease (AD), and amyotrophic lateral sclerosis (ALS) are the four age-related neurodegenerative diseases that are most frequently researched. Deficits in episodic memory, visuospatial abilities, language, executive functions (organization and planning), and apraxia are the various features of AD. Amyloid plaquesnd neurofibrillary tangles are associated with reactive astrocytes and activated microglial cells in addition to neuronal loss (Abd Rashed et al., 2021).

Aromatherapy and Massage

Aroma is a fragrance or pleasant smell, while therapy is a treatment. These two terms are combined to form the word "aromatherapy." The essential oils' usage for physical and psychological well-being through massage or inhalation is known as aromatherapy and massage therapy. Aromatherapy is the application of pure essential oils from aromatic plants (such as rose, sweet marjoram, and peppermint) to alleviate various health issues and enhance overall quality of life. Aromatherapy is said to have therapeutic benefits that include easing pain, promoting sleep and relaxation, and lessening symptoms of depression. As a result, aromatherapy has been used to lessen disruptive activity, encourage sleep, and increase motivated behavior among dementia patients (Forrester et al., 2014). As a result, aromatherapy cannot be applied to massage essential oils. Aromatherapy is limited to the inhalation of aromatic materials to produce either physiological or psychological benefits. However, the application of essential oils and their volatile components in medicine through massage or inhalation has grown all over the world. When working with essential oils in massage, caution should be used. Certain essential oils may pose a risk of toxicity.

Inhalation

The three basic methods of using essential oils are ingestion (via the digestive system), topical absorption (through the skin), and inhaling (via the respiratory system or olfactory nerves). The biological activity and aroma of essential oils are determined by their chemical composition, which is a blend of many organic components. They can be divided into some types based on their aroma, including citrus, herbaceous, camphorous, flowery, woody, earthy, minty, and spicy (Aćimović, 2021). The oils inhibited neurons in the central nervous system via the GABA-ergic neuromodulation pathway. This outcome is caused by elevated amounts of GABA in the brain (Edris, 2007). One of the prevalent psychological and behavioral issues that college students face is test anxiety, which can lead to subpar academic performance or even failure. College students may find aromatherapy to be a helpful way to lessen test anxiety, however, its exact effectiveness has not yet been thoroughly established (Luan et al., 2023).

Essential Oils Against Cancer

Constituents of natural essential oils are crucial I the treatment and prevention of cancer. When tested on various cancer cell lines of humans, including colon cancer, breast cancer, gastric cancer, tumors in the human liver, glioma, lung tumors, leukemia, and others, essential oils and their distinct fragrance components show cancer-decreasing effects. One of the most dangerous tumors in humans is glioma. Sesquiterpene hydrocarbon element, which is present in trace levels in many oils, has been shown to have a major impact on the treatment of gliomas. It extended the quality of survival time of glioma patients (Edris, 2007). Their chemopreventive properties come from a variety of mechanisms, including antimutagenic, antioxidant, anti-proliferative, immune function and surveillance enhancement, enzyme induction and enhanced detoxification, modulation of multi-drug resistance, and synergistic mechanism of volatile constituents (Bhalla et al., 2013). The antimutagenic properties of essential oils are ascribed to specific processes, one of which is the reduction of mutagens' ability to penetrate cells (Kada and Shimoi, 1987). Thymus vulgaris, Carum copticum, origanum, and oregano all have volatile oils that contain carvacrol, a phenolic monoterpene.
Various targets of EOs for cancer prevention are represented in Fig. 2.

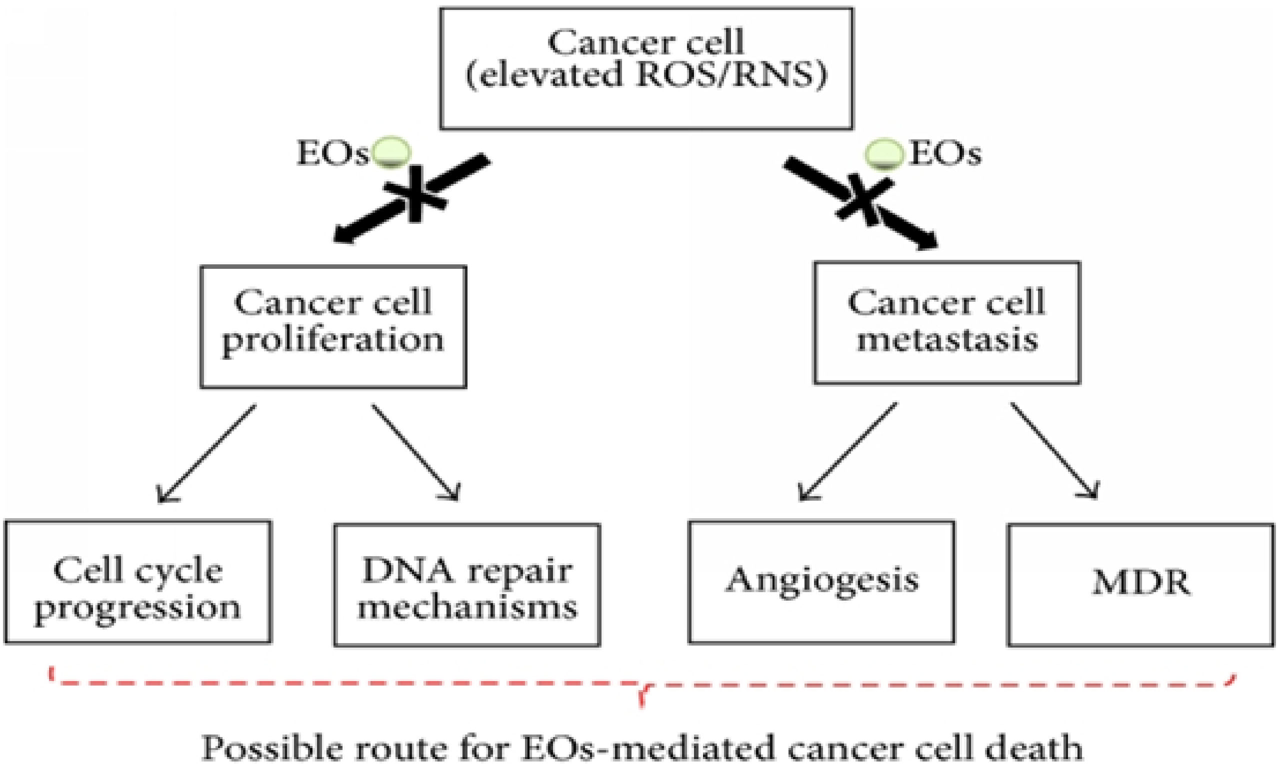

Fig. 2: Targets of EOs

Treatment of Cardiovascular Diseases

Atherosclerosis is a process in which plaque deposits accumulate in the intima, the artery's innermost layer. Over time, plaque can severely reduce blood flow, which might result in major health issues. An important factor in the onset of disease is elevated levels of oxidatively damaged (LDLs) low-density lipoproteins in cholesterol. The volatile components present in essential oils and their scent have demonstrated having antioxidative properties against LDL oxidation. One monoterpene hydrocarbon that is particularly effective at preventing the oxidation of LDL's protein and lipid components is terpinolene. The prolonged degradation of the basic carotenoids of LDL is the actual reason of this inhibition, not the safeguarding effect of intrinsic α-tocopherol like with certain flavonoids. Essential oils rich in phenolic substances, such as thymol and eugenol, have the strongest antioxidant action against LDL oxidation and can change the affinity of LDL particles for the LDL receptor (Naderi et al., 2004).

Antimicrobial Activity against Microbes (bacteria, Virus, and Fungi)

EO chemicals' antibacterial action has been well studied. It was discovered that a number of *Clostridium perfringens* strains were sensitive to thymol, citral, limonene, carvacrol, and cinnamondehyde when grown in anaerobic environments. According to in vitro research, combining various EO compounds may have a stronger antibacterial impact than taking each one alone, suggesting a synergy between separate actions. One benefit of several essential oils is their ability to prevent the growth of possible infections. The many components present in essential oils (EO), such as terpenes, phenylpropanoid, and aldehydes, confer reactivity on each EO based on its composition and nature, rendering it effective against a broad spectrum of infections (Aljaafari et al., 2021). Two groups of different biosynthetic origins are among the key constituents of essential oils that define their biological qualities. One group is terpenoids and terpenes and another is made up of aliphatic and aromatic components that have lower molecular weights. Terpenes are hydrocarbons that are created when numerous isoprene units (C_5H_8) are joined. Acetyl-CoA starts the process of terpene synthesis in the cytoplasm of plant cells, which then moves through the mevalonic acid pathway. Terpenes can be reorganized into cyclic structures by cyclases, which have a hydrocarbon backbone. This can lead to the development of either monocyclic or bicyclic structures.

Terpene biosynthesis consists of the following steps: synthesizing isopentenyl diphosphate (IPP) precursor; adding IPPs one after the other to form the prenyldiphosphate precursor of the various classes of terpenes; modifying allylic prenyldiphosphate by terpene-specific synthetase to form the terpene skeleton; and secondary (redox reaction) enzymatic modification of the skeleton to confer functional properties on the various terpenes. The primary two types of terpenes are sesquiterpenes ($C_{15}H_{24}$) and monoterpenes ($C_{10}H_{16}$), although there are longer chains like triterpenes ($C_{30}H_{40}$) and diterpenes ($C_{20}H_{32}$). Among the components of essential oils having antimicrobial activity are limonene, eugenol, p-cymene, estragole, menthol, geraniol, anethole, thymol, cinnamonyl alcohol and γ-terpinene (Chouhan et al., 2017). The capacity of EO to inactivate or inhibit bacterial development is referred to as its antibacterial activity. Clove extract demonstrated the strongest antibacterial activity, but grape seed cinnamon, pomegranate peel, clove and oregano were also found to be beneficial (Aljaafari et al., 2021).

Different essential oils work in different ways; some attack the outer membrane of bacteria, while others go after the efflux system of proteins in that membrane. Since EO are hydrophobic, they can pierce bacterial cell walls, which in turn causes the walls to break down, increasing permeability and releasing intracellular contents. Several studies demonstrated that the constituents of essential oils (EOs) target the cellular membrane, as demonstrated by the effects of applying oregano and thyme EO on the membrane of L. monocytogenes. This process is known as membrane disruption. Since EO compounds are hydrophobic by nature, this increases the permeability of bacterial membranes and increases the possibility that bacterial contents may leak out (Nazzaro et al., 2013).

Essential oils obtained from plants could be used for treating the viral diseases. A virus is a tiny particle (20–300 nm) that is made up only of genetic material encased in proteins and lipids. They carry out self-replication by infecting host cells. Viral disease continues to be a major global health concern. The usual method for figuring out the mechanisms of action of EOs, including their component parts, against viruses is to manipulate time-of-addition assays. The EOs are applied to cultured cells one hour before the virus is introduced (pre-viral infection). A negative result means that host cell receptors are not blocked by EOs, which would impact viral attachment. As an alternative, viruses are pretreated for one hour with EOs and then incubated with host cells at the same time (simultaneous viral infection). If the test is successful, it means that EOs disrupt free virions by changing the structure of the virus envelope or hiding the viral proteins that are required for the virus to bind to its surface and enter the host cell. Alternatively, EOs are added at several points to the infected cells (post viral infection) during the viral infection lifecycle (from penetration to progeny production). It is possible to approach the point in the viral infection cycle where EOs can combat viruses. To date, the most popular method for examining the general intracellular and intercellular inhibitory qualities of EOs is the time-of-addition experiment (ma and yao, 2020).

Compared to bacterial infections, fungal infections are caused by eukaryotic organisms, which makes it more challenging to identify their existence and administer the proper therapeutic therapy. The chitin structure found in the cell walls of fungi, which is lacking in human cells, makes them an ideal target for highly toxic antifungal medicines. The natural product for inhibiting fungi is essential oils (EOs). In actuality, a variety of essential oils that are derived from several herbs and plants demonstrated potent antifungal characteristics. Similar to other phytochemicals, EOs have the ability to prevent the growth of microbes and the development of biofilms through specific mechanisms. This is a particularly valuable aspect: Microorganisms are known to initiate a certain mechanism that results in the synthesis and manufacturing of chemicals, signals of microbial communication, and also the development of pathogenicity parameters, like the formation of biofilms, in addition to a specific growth threshold value. Many essential oils have broad antibacterial qualities that make them useful for preventing microbiological deterioration, maintaining quality and food safety, and extending the shelf life of food. The lipophilic and smaller molecular weight characteristics of terpenoids/terpenes may account for the antibacterial or antifungal activity of essential oils. These characteristics can cause a cell to rupture and die, or they can stop food-spoilage fungi from proliferating and germinating. Antifungal agents have the ability to deactivate fungi by interfering with the function and structure of the organelles and its cell's membranes, as well as by blocking the creation of proteins or nuclear material (Nazzaro et al., 2017).

Essential Oils and Antibiotic Agents

Many essential oils (EOs) have antibacterial qualities. Lavender essential oil demonstrated antiviral efficacy against the Herpes simplex virus type 1, but it also exhibited far stronger antibacterial action. Lavender essential oil (EO) is used in dermatology to treat ulcers, burns, and scars that are hard to heal.

Since thyme EO was effective against Herpes simplex, it demonstrated antiviral action. Additionally, after 30 minutes of exposure, this EO showed 100% inhibitory efficacy against the influenza virus in the liquid phase. However, thyme essential oil's primary impact is related to bacteria. The thymol chemotype of T. vulgaris L. exhibits particularly significant bacteriostatic activity against most Gram-negative and Gram-positive bacteria.

Nanomedicine Formulation of Essential Oils

The usage of natural prodrugs derived from plants is growing across many industries, including the cosmetic, pharmaceutical and food ones. These volatile, oily liquids that are biologically active are produced by aromatic and medicinal plants and have a unique smell. Although EOs have a great deal of promise for anticancer, antibacterial, antiviral, and antioxidant effects, they are frequently characterized by high volatility, low stability, and a significant risk of degradation when exposed to moisture, light, heat, or oxygen. The use of nanotechnology in medicine, or nanomedicine, may provide effective answers to these issues. The technique is based on building nanostructures in which the natural prodrug is attached to or enclosed in submicron-sized capsules or nanoparticles that guarantee their regulated distribution, solubility in water, and targeting characteristics. When compared to either free EO or a nanoemulsion, nanocapsules demonstrated a greater anticancer impact against the HepG2 liver cancer cell line. (AbouAitah and Lojkowski, 2022).

Future Prospective

An increase in the permeability of the pathogen cell membrane and the subsequent leakage of internal components can have a negative impact on cell metabolism, according to the functional groups of the EOs. To fully understand the potential of EO, determine the optimal dosage, and discover any potential side effects, additional research is needed to conduct clinical studies and long-term examinations to determine its efficacy in vivo. Essential oils also play a major role in reducing the prevalence of bacteria that are resistant to antibiotics.

Comprehensive studies may be conducted in the future to assess or forecast how microorganisms may respond to EO following prolonged or subchronic exposure. In order to better understand the pathways and mechanisms involve in the development of essential oils as prospective antimicrobial agents, several researchers proposed that the antibacterial action of EO should be examined during the lag phase in bacterial growth. Therefore, specialists from a variety of fields are required for the development of more potent therapeutic drugs; these fields include genetics, structural biology, genomics, and bioinformatics. Furthermore, for successful mitigation, it is essential to build extensive epidemiological networks that can report the emergence of novel microorganisms and raise public awareness.

Conclusion

The purpose of this chapter is to explain the essence of oils and their function in human health. Essential oils are substances that are inherently flammable. Essential oils have various uses beyond just adding flavor and aroma. The medicinal potential of essential oils is immense. Essential oils enhance the activation of white blood cells, making them more effective in flushing out germs and other pathogens.

As a result, essential oils, like many other plant-based medications, have multiple therapeutic effects for various illnesses, including cancer. More new essential oils and unidentified compounds should be screened for potential anticancer activities. Depending on where they originate, they each have distinct methods that contribute to lessening the severity of the condition. Essential oils are employed more often in the field of health, primarily on the body's exterior tissues. It is widely utilised worldwide, and as a result of its increased use, the market for essential oils is expanding quickly and gaining significance every day.

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