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Comprehensive Review of Essential Oils Prospects for Health, Nutrition, And Omics for Optimal Well-Being

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Abstract

Essential oils are becoming increasingly popular due to their fragrance and medicinal properties and have been studied all over the world. Essential oils are volatile in nature and can be extracted from natural plants in a variety of ways. They can be obtained from flowers, roots, stems, leaves, seeds, and gums can all provide them. These days, a variety of plants, including lavender, mint, and cinnamon, are employed for this purpose. These plants use different extraction procedures in labs according to their chemical composition. Steam distillation, cold passing, solvent extraction and supercritical fluid extraction, ultrasound assisted extraction, and microwave assisted extraction are used. In this review, we examine the available studies that demonstrate the health effects of essential oils on human health. By doing this, we demonstrate that essential oils and some of their constitute parts have an anti-inflammatory, antibacterial, antiviral, and antioxidant qualities in addition to its applications to alleged psychogenic effects like stress relief, depression treatment, and sleeplessness relief. In future, due to emerging trend of using essential oils as replacement, businesses and entrepreneurs take advantage of this and add thesis oils in their products.

Keywords: Essential oils, extraction procedure, psychogenic effects

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1. Introduction

Traditional medicine has traditionally utilized aromatic plants for their medicinal and defensive properties, in food to impart flavor, but also used as antioxidant, anti-inflammatory and antimicrobial agents [1]. The lamiaceae family of plants which are medicinal in nature includes peppermint and rosemary, which have a variety of bioactivities, including antioxidant, antimicrobial, antipyretic and respiratory protective properties [2]. Phytotherapy, now the well-known area of natural medicine in Europe. Dioscorides' "De Materia Medica" is one of the earliest and most comprehensive pharmacognostic manuals on plants, animals, and their chemicals, including essential oils and fatty acid [3]. M Kumar *et al.,* B Zhang, J Potkule,K sharma and Radha performed cancer cell study using cotton seed oil. Cotton seed oil helps reduce the risk of illness because it acts as anti-inflammatory, anticancer, antiallergic and antioxidants as well as cardio protective. Gossy-pol are present in cotton seed oil and performs function as an anti-proliferative activity that causes toxicity towards the proliferation of cancerous cells since gossypol has an ability against various cancer cells because of its anticancer properties and also help to protect cancer types includes breast, colon, ovary and prostate cell lines [4]. F Gunstone *et al*., performed research on soyabean oil. plant seeds are used to extract large amounts of soybean. In the USA, it is most popular food oil. It contains varying amounts of fatty acids, such as 61% polyunsaturated fatty acids, 25% monounsaturated fatty acids, & 15% saturated fatty acids [4].

Additionally, it has important fatty acids including linolenic acid that is 85% and alpha linolenic acid that is 11%. A variety of food products, including cooking, margarine, mayonnaise, and salad oils, include about 48% soybean oil. As a result, it had nutritional value but also demonstrated oxidative instability [5]. For the synthesis of insecticidal essential oil, roots of carlina acau lis have been investigated and calamintha leaves have been investigated as anticorrosive agents [6]. An active component of thymus vulgaries, thymol is used to treat menstrual cramps, while deverra spp. Which produces essential oil, has ability to heal wounds. A crucial component of citrus essential oils is limonene monoterpenes which are thoroughly investigated for flavor and aroma industry. Similarly, geranial from lemongrass is used in antiaging skincare products, menthol from peppermint used to relieve migraines & for tooth pain eugenol from cloves are being investigated. Owing to many medicinal applications of

essential oils, such as their antiplasmodic, hypnotic, sedative, analgesic, neuroprotective, antimicrobial, antioxidant and cytotoxic, anti-inflammatory, antiallergic, antitumor and immunoregulatory qualities [7]. The prevalence of chronic stress and its detrimental effects on both physical and mental health have alarmingly increased in the twenty-first century; according to a global adult population survey conducted between 2018 and 2024, 31% of respondents said that stress was the largest health issue in their nation.1

With 12% of a large English sample contacting a practitioner in the previous 12 months, complementary and alternative medicine (CAM) has grown in importance as a component of healthcare for such diseases, with aromatherapy being the second most common modality [8]. Essential oils have been shown to lower self-reports of stress and have a positive effect on physiological markers like cortisol and blood pressure especially inhaling the scents of lavender essential oil. It is anticipated that the essential oil demand for the pharmaceutical and medicinal uses would rise, propelling the global market. To put it another way, in the market of essential oils, businesses must recognize the significance of developing innovative business models and services. The field of essential oils is always changing due to ongoing study and significant technology breakthroughs. The uses of essential oils have grown beyond conventional methods thanks to contemporary company innovation techniques [9]. For example, essential oils are currently used in household cleansers, food and beverage formulations and personal care products. As a natural preservative, studies have concentrated on investigating the antibacterial capabilities of essential oils and evaluating their effectiveness in treating a range of medical diseases. In this review, we will thoroughly study how essential oils can be extracted from different extraction techniques and how these oils could be beneficial for health of humans as well as for nutrition by reducing stress and psychological effects.

1.1. Essential oils

Fragrant extracts from different plants are called essential oils. Species of plants from which they are taken decide their makeup. These oils contain over 200 different constituents. Recently, these essential oils have gained popularity in a variety of industries, including food flavoring, aromatherapy and natural treatments of pharmaceutical, because of their uses, key ingredients, & unique characteristics. As a result, their anti-inflammatory, antibacterial, analgesic and antioxidant qualities have all been examined [10]. Over the past ten years, essential oils more than 3000 have been studied and characterized both chemically and physically; about 150 of these essential oils are produced on industrial scale [11] by using hydro distillation [12] microwave-assisted hydro distillation, ultrasound-assisted hydro distillation, cold pressing and solvent extraction various parts of plant, such as leaves, petals, seeds, stems, rhizomes and roots were used to extract oil [9].For example, ginger roots and rose petals for extraction of essential oils have been studied. The main reason for investigating plants for valuable volatile compounds like terpenes, esters, phenols, alcohols and ketones is that these molecules exist in very small quantities as diverse metabolites, due to their complexity and diversity, are difficult to synthesize [13]. Essential oils has a lot of benefits for humans being including reduction of stress and other neurological properties.

1.2. Benefits of essential oils

Essential oils can be transferred to the body through aromatic herbs, dietary supplements, and spices. Essential oils can be obtained by a variety of specialized food sources, including orange and citrus peel, dill, caraway, cherry, spearmint, caraway, black paper and lemongrass. Through their diet or surroundings, people are frequently exposed to essential oils. On the assessment of essential oil intake, however, there is a dearth of knowledge. Essential oils can easily pass through the blood brain barrier and be absorbed from the food matrix or as pure products. This latter characteristic results from volatile chemicals which are small and lipophilic in nature. The first step in the activity of essential oils is their entry into the human body through of three major routes including, direct absorption by inhalation, or diffusion through skin tissues [14]. Essential oils obtained from different plants vary in their chemical composition and have different effects on humans as well as animals. Different plants have different compositions by nature.

2. Composition of essential oils

Essential oils are organic composites that are volatile in nature and contain intricate blends of many substances, frequently numbering more than 500. Among the various compounds included in essential oils derived from different plants are linalool and camphene. Essential oils contain substances like menthol and camphor. Eucalyptus, linalool acetate, linalool, and perillyl alcohol are the main ingredients of Lavender, which is one of the most widely used essential oils. Secondary components like caffeic acid, tannins, 1,8-eucalyptol, propanone, and bitter compounds are produced by plants because of secondary metabolism. These substances are produced and present in a wide variety of plants parts, including flowers, roots, leaves, bark, seeds, fruit, resins, and so on. Chemical makeup of essential oils that are obtained from different plant sections varies as well. Each of these essential oils is recognized by ketones, terpenoids, fragrances, aldehydes, ethers, epoxy compounds and other chemicals [15]. Below table 1 shows chemical formulas and application of essential oils by their composition.

3. Extraction techniques

Variety of extraction techniques are used for essential oils. Two major types are used one is conventional and other is modern innovative technique.

3.1.1. Conventional techniques

This is old methodology for extraction of essential oils. Here we discuss these three ways which include cold pressing, distillation and solvent extraction.

3.1.2. Cold pressing

The first method for the extraction of essential oils is cold pressing, which is also known as expression. This technique was developed many years before humans discovered distillation process. One of the advantage of cold pressing is that it generates little or no heat, even though the yields are modest [16].The mechanical cold pressing method, uses citrus peels, including rupturing the oil glands with pressure or abrasion, ejecting the oil, and then cleaning it away with a

water spray. To improve the quality and quantity of extracted essential oils, enzymes pretreatments have been studied due to drawbacks of this method, such as low yield extraction and low purity.

3.1.3. Distillation

The traditional method for essential oils for removing volatile substances from plant matter is distillation. During the distillation process, fragrant plants that are used for extraction, when encounter steam or boiling, water evaporate and releases their essential oils. Water/steam distillation, hydrodynamic distillation and steam distillation are three different methods of distillation [17]. In this method, steam is created in a boiler and then pumped via a pipe while the plant material is placed on a tray with holes in the bottom of the container. Condensed distillate is done by combining water and oil; oil and water are parted by using a Florentine flask, which uses the variations in their densities to do this.

3.1.4. Solvent extraction

Because of their nonpolar and hydrophobic characteristics, essential oils can be extracted using organic solvents, especially those made from fuel [18]. Solvent extraction is process in which solute that are in contact with one another is distributed across two immiscible liquid phases[19]. In this technique, a material is transferred from a matrix using a liquid in which the material is soluble.

3.2. Modern techniques

Due to need to reduce CO_2 emissions and rising energy costs, the food , chemical, and pharmaceutical industries have recently placed a great energy prices and the need to lesson CO_2 emissions [20]. Supercritical fluid extraction, microwave-assisted extraction, and ultrasound-assisted extraction are among the oil extraction techniques under investigation.

3.2.1. Microwave assisted extraction

In recent years, microwaves used by many researchers to extract essential oils. The findings demonstrate that the conventional methods such as hydro distillation or Soxhlet extraction need twice as much time both qualitatively and quantitatively as compared to microwaves extraction which requires less than 30 minutes [21]. Principles involve heating the sample mixture using microwave radiation, Instantaneous microwave heating occurs inside the sample because of ionic conductance and dipole rotation, which results in extremely quick extraction times. One advantage of microwave heating is the breakdown of weak hydrogen limitations. Because cell structural changes occur by electromagnetic waves that lead to microwave extraction. It differs from the extractive processes utilized in conventional techniques. Environmental impact is lessen by using microwaves by releasing less carbon dioxide in their atmosphere since they automatically shorten the extraction time and solvent volume [22]. Table 2 represents different essential oils obtained from microwave assisted extraction.

3.2.2. Ultrasound-Assisted extraction

The potential industrial use of ultrasound for herbal extracts has been recognized by phytopharmaceutical extraction business[23]. By using organic solvents to separate the compounds that are volatile in nature from natural materials at room temperature, ultrasound-assisted extraction minimizes solvent volume, speeds up processing, & increases extract yield compared to traditional procedures [24].

3.2.3. Supercritical fluid extraction

Supercritical fluid extraction can be used as extraction process for plant components like lipids, tastes and essential oils. In terms of speed, chemical selectivity, and environmental friendliness, this emerging approach outperforms traditional extraction methods. In order to use solvents in their supercritical state, supercritical fluid extraction requires temperature and pressure over their critical points. Distinct characteristics of supercritical fluid, which fall between those of gas and a liquid, are determined by its temperature, concentration, and pressure. Because they mix up the liquid density with the gaseous penetrating ability, these liquids are effective and selective solvents. It is perfect supercritical solvent for plants extraction because of its non-toxic nature and capacity to reach supercritical operation at pressures comparable to room temperature while keeping comparatively low carbon dioxide concentrations [25].

4. Comparative evaluation of traditional vs nontraditional extraction techniques

Depending upon extraction techniques the production and content of essential oils may vary significantly. The most popular methods for extracting essential oils are expression and distillation which is considered as old method. The serious issues associated with these traditional techniques is lengthy extraction times, and deterioration of essential oils. As compared to traditional techniques, the clean and effective way to extract essential oil is supercritical fluid extraction that uses co2 but one of the drawbacks of this technique is expensive approach. Another promising extraction technique is ultrasound assisted extraction technique that can greatly improve both conventional and novel extraction procedures despite of its high cost [26]. We might conclude that there is no perfect way, each extraction process is specific to a certain plant. Measurement of extraction efficiency is also influenced by use of appropriate standard procedures. However, the bioactive compounds and the products that are formed from them becomes valuable in market, it is investigated that more advance techniques will discover in future [27].

5. General effects of essential oils on health

Essential oils exposure can happen through a variety of means, including ingestion, inhalation, dermal applications, and massage. Essential oils are well known for their number of health benefits, including their antiviral, antibacterial, and antibiotic qualities [28-29]. They have been used to cure variety of conditions, including sleep disorders, cardiovascular problems, Alzheimer's illness, cancer and labor pain during pregnancy. For reducing stress, they are also well recognized [28].

5.1. Antimicrobial activity

Common natural compounds with range of medicinal uses, in the light of rise in antibiotic resistance essential oils have been investigated as possible antimicrobial

agents [30]. Clinical investigations have shown the bactericidal, virucidal, and fungicidal properties of these naturally occurring chemicals. Additionally, because of its antibacterial activity and antioxidant properties, it has been recommended that these plant extracts may be utilized not just to treat the skin diseases, but also helps to preserve food [30-31].

5.2. Action against Antibacterial properties

Numerous theories have been put out regarding the antibacterial properties of essential oils. Essential oils help against antibacterial properties by mainly cause the cellular architecture to become unstable, which results in increased permeability and breakdown of membrane integrity. This interferes with a range of cellular processes, such as membrane coupled energy production, membrane transport, and other metabolic regulatory functions. Both the cell's outer membrane and cytoplasm may be impacted by the essential oils [32]. Essential oils can quickly pass through cell membranes because they are lipophilic in nature. It has been found that essential oils of different medicinal and aromatic plants increase the permeability of bacterial cell membranes, causing ions to be lost and cellular components to flow out [33-34]. Essential oil's antimicrobial properties is also connected to decreased proton pump malfunction, membrane potential, and ATP depletion [35]. For instance, by increasing intracellular K+ ion leakage, changing cell permeability, and disruption cell respiration, the growth of S. aureus and E.coli can be prevented by using tea tree oil [36]. The fatty acid arrangement, phospholipid bilayers, and polysaccharide molecules may be disturbed by the passage of essential oils through the cytoplasmic membrane and cell wall. Trans cinnamaldehyde is method of action that interferes with cellular processes by penetrating the cell's periplasm [37].

5.3. Action against antifungal properties

Essential oils that exhibit antifungal properties are comparable to previously described antibacterial processes. Essential oil exposure to antibacterial causes irreversible cell membrane damage, which causes the cellular components to coagulate. Essential oils damage the yeast by disturbing cell membrane simply by creating membrane potential across the membrane and interfering with ATP synthesis[38]. Through the process of permeabilization, essential oils can penetrate and damage the fungal cell wall and cytoplasmic membranes, which causes the breakdown of mitochondrial membrane. Changes in the electron flow within the pathway of electron transport system are the source of this. Additionally , In fungal pathogen infected cells, this could harm the lipids, proteins , nucleic acid contents of cells[39]. By influencing ion channels, particularly ca2+ ions, ATP pools, proton pumps, the depolarization of mitochondrial membranes occur due to essential oils because these oils interfere with membrane, lowering the membrane potential. This alteration in the fluidity of membrane may result in electrolyte leakage and impede calcium ion concentrations, cytochrome C pathways and protein metabolism. Consequently, the permeabilization of inner and outer mitochondrial membrane causes necrosis or apoptosis that results in cell death [40].

5.4. Action against antiviral properties

Currently, a good substitute for viral illness could be a number of essential oil [41]. To understand fully the antiviral properties of essential oils, more research is still needed. Some of the documented methods of action of essential oils are discussed in this section. Essential oils affect the outer lipid layer of viruses that become inactive and cannot enter the host cell and thus prevent infection. The mode of action against viruses includes altering pathways of phenyl propanoid and impeding cellular DNA polymerase to prevent virus multiplication.

6. Antioxidant activity

Double bonds are responsible for antioxidant capacity in ethers, phenols, alcohols and ketones. Phenolic compounds are compromised by phenylpropanoid and terpenoids, eliminated by transfer of hydrogen atom and highly sensitive towards radicals of peroxyl [42]. Rancidity is produced by oxidation of carbohydrates like lipids and all other food products. By using DPPH, effect of oregano, clove and thyme was concluded by author. Above all of these, highest inhibition of about 95% due to clove EO was concluded by results. As compared to other EO factors, clove has high ability to interact to free radicals , in order to lower the oxidation of lipids and main component responsible for performing all these functions is eugenol [43].

7. Essential oils used as food preservatives

Essential oils are used as flavoring agents as well as major sources of antimicrobials for preservation of food in many foods industry. To use essential oils for preservation of food, must know the following characteristics including lowest inhibitory concentration, mechanism of action, way the food matrix effects the antimicrobial characteristics and range of specific organisms. EO has been used as flavoring agent ad food additives and classified as safe for food [44]. The main aim of packaging is to increase the quality and self-life of food. Deterioration occurs because of traditional food packaging methods that contain compounds produced when packaging interacts with food products, these compounds released into food and contaminate it. Antioxidants and their constituents are responsible for reducing oxidation of lipids and remove pathogen microorganisms. When they added in food it will increase the shelf life because many oxidants have antibacterial and antimicrobial characteristics. As a result, synthetic additives are replace by anti-oxidants [45]. Now a days essential oils are not used for preservation of food because high amount is required to preserve food and to do antimicrobial activity.

8. Pharmaceutical application of essential oils

A lot of pharmacological characteristics of essential oils have been used. In previous years, business and people have developed new ways to study the effect of different pharmacological products. Many Lamiaceae species including Lavandula angustifolia Mill, Mentha haplocalyx, scutellarin Georgi, Pogostemon cablin are all used in China. These plants and their extract have been used as antibacterial, antitumor, anti-inflammatory and antioxidant agents [46] . To fight a variety of infectious disorders, essential oils have been extracted from plants which have ability to control pathogenic microorganisms. A variety of medicinal plants like fennel, peppermint and thyme have been used to control the growth of bacteria like gram negative and gram-positive bacteria, fungi, yeast and viruses which are all derived from essential oils.

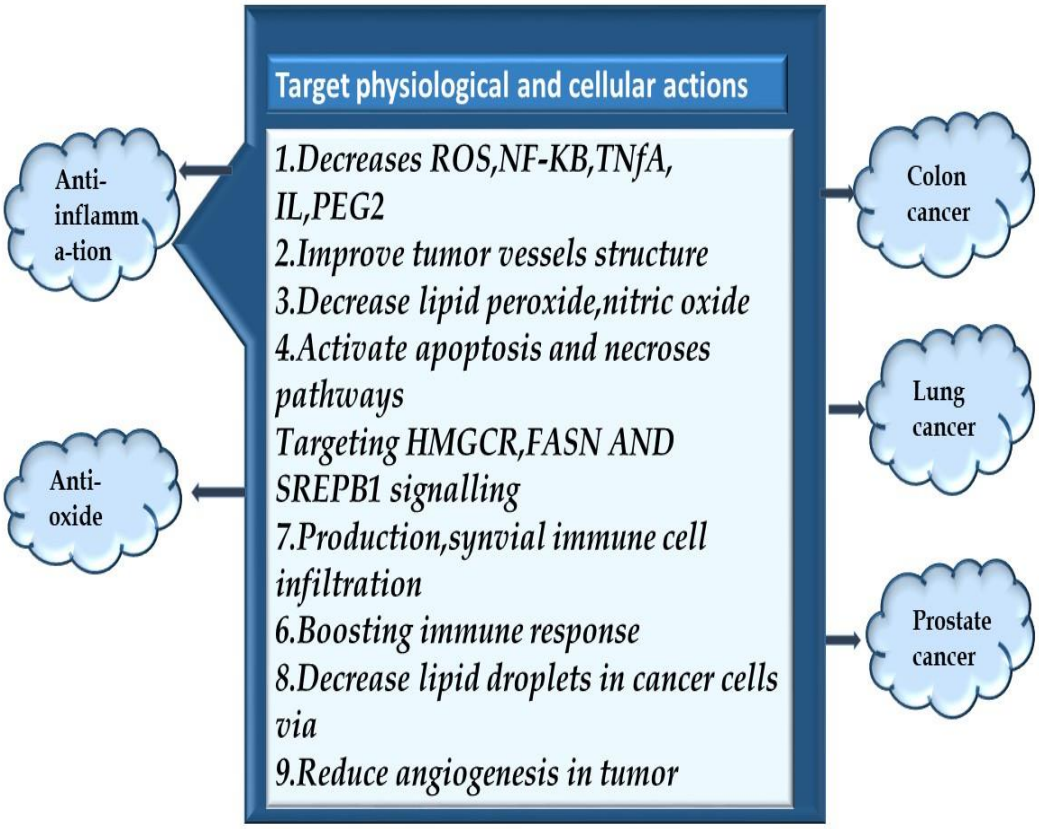

Fig 1: Mechanism of action of essential oils against cancer

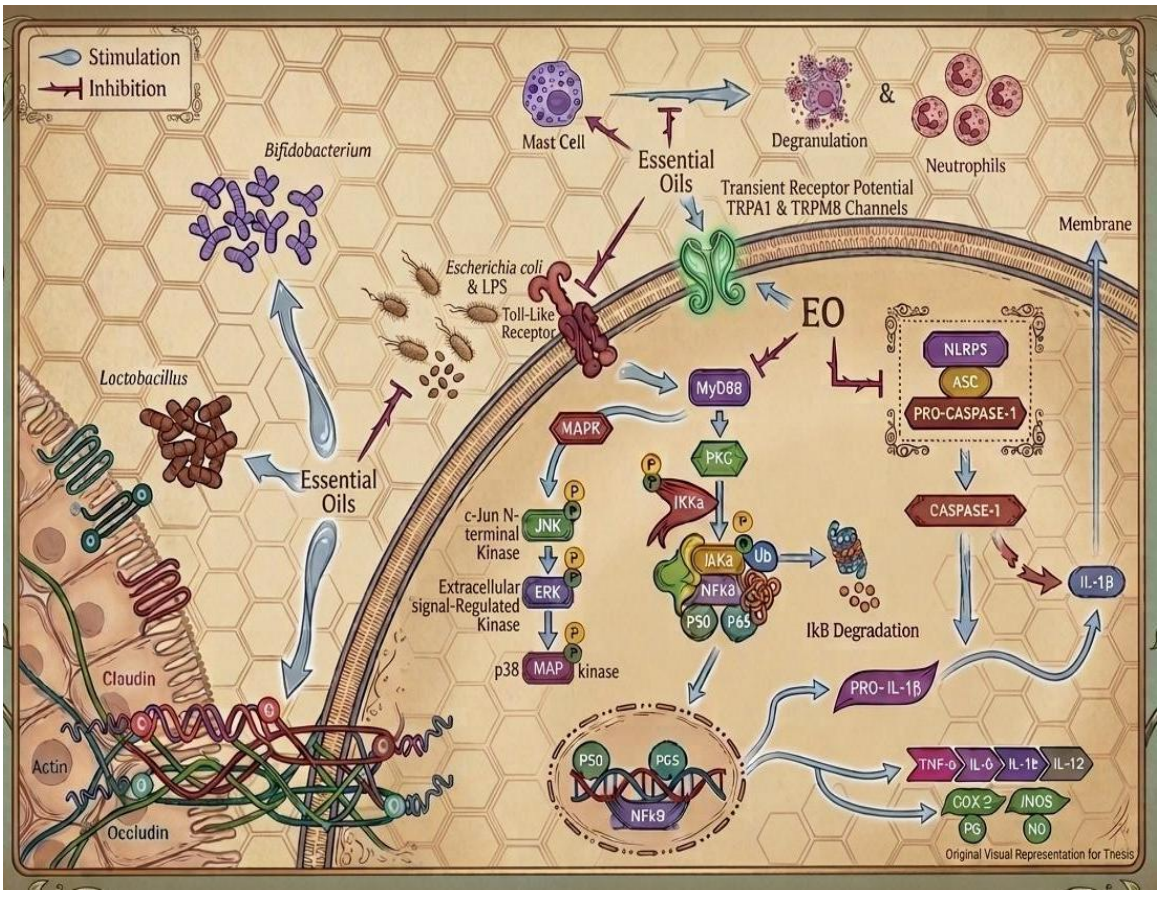

Fig 2: Mechanism of action of essential oils against inflammation

Table 1: Various compounds of essential oils, their chemical formula and applications

Essential components	Molecular weight	Plant source	Chemical formula	Refractive index	Applications	References
Terpenic oxides cis rose oxides	154.25	Rosa damascene	$C_{10}H_{18}O$	1.454	Anti-inflammatory agents	[48]
Ketones alcohol camphor	152.23	Lavendula strechas	$C_{10}H_{16}O$	1.46	Anti-anxiety, sedative, anti-inflammatory	[49]
G Terpinene	136	Origanum vulgare	$C_{10}H_{16}$	1.475	Anti-oxidant	[50]
Oxygenated sequiterpenes	222.34	Matricoria recuita	$C_{15}H_{26}O$	1.496	Anti-microbial, anti-oxidant	[51]
Cinnamaldehyde	132.16	Cinnamomum zeylanicum	C_9H_8O	1.621	Insecticides, fungicides	[52]

Table 2: Different essential oils produced by microwave assisted method

Essential oil	Equipment used	Advantages	References
Laurus nobilis	Water solvent, microwave oven	Energy efficient, no solvent, safe to use	[53]
Eureka Marsh seedless lime, Tangelo Seminole	Microwave hydro diffusion, gravity working at atmospheric pressure	Short time required, high purity extraction, green extraction	[20]
Elettaria cardamomun	Microwave oven	No solvent use, less extraction time	[54]
Lavandula angustifolia Mill	Microwave system distillation	Faster than steam distillation	[55]
Cuminum cyminum	Microwave adsorption medium	Energy efficient, Rapid	[56]

9. Therapeutic applications of essential oils

9.1. Used against cancer

Cytotoxic drugs are used in cancer chemotherapy that effect the healthy cell growth and effect the cell proliferation. These medications have no side effects on normal cell growth. chemotherapy used, Chemo preservation is done to remove carcinogen, to control cell death due to tumor and to inhibit cell proliferation as well [47]. Monoterpenes that contain compounds including perillyl alcohol and limonene for effective anti-cancer properties as well as to protect normal cells from carcinogenesis. It has been concluded that chemo preservatives and chemo therapeutic properties are used for treatment of cancer cells in advanced and initial stages. Essential oils like monoterpenes are used for treatment of anticancer properties in model of liver, breast and lung cancer (Fig 1) [57].

9.2. Used as antidiabetic agent

Diabetes is a condition in which body does not form enough insulin. Investigators exploring the potential benefits of essential oil have found which its use as hypoglycemic agents. Researchers are trying to discover more advantages of essential oils. In diabetic rabbits' models rosemary essential oil showed hyperglycemic and insulin release inhibitory effects [58]. In diabetes , various essential oils like fennel, cinnamon, oregano and cumin have ability to increase insulin sensitivity as well as decrease the glucose in tolerance test of rats [59]. To control diabetes, Catharanthus roseusis essential oil is used. Moreover, in many diabetic patients, aloe vera work as natural therapy and allium sativum responsible for decreasing the insulin removal, lowers blood glucose level and enhance secretion.

9.3. Used as cardiovascular disease

A condition in which plaques deposit on surface of interior layer of arteries that results in serious health risk by decreasing blood flow is called atherosclerosis. When antioxidants are taken in high amount to avoid oxidation of lipoproteins , atherosclerosis will be slowed [60]. Aromatic volatile components of essential oils contain antioxidant effect against oxidation process of low-density lipoproteins. A component of terpinolene that is monoterpene that is responsible for oxidation of proteins as well as low density lipoproteins. Garlic essential oil is very important for healthy as well as heart patients that decrease the cholesterol in body and increase concentration of high-density lipoproteins. To lower the systolic blood pressure in most rats' models, combination of different essential oils is present like cumin, oregano and cinnamon oils.

10. Recent approaches to essential oils

Research in the field of essential oils has experienced a huge interest in recent years, which leads to great discoveries and revolutionary innovation. This section highlights the most recent scientific discoveries on essential oils and new extraction techniques.

10.1. Mood regulation and neurological effects

The influence of essential oils on the neurological system has gained scientific interest over recent years. The aim of research on essential oils is to investigate how these oils help to reduce stress, anxiety, and depression that is most common in recent years. In this regard, certain oils, especially bergamot oil have been studied to alter neurotransmitters, offering insights into their possible effects on mental health [28].

10.2. Anti inflammation and analgesic effects

Because of anti-inflammatory and pain-relieving properties of essential oils, it has gained attention in the field of inflammatory disorders and pain-relieving system. However, oils like ginger, eucalyptus, and peppermint oil helps to reduce pain and have anti-inflammatory properties investigated by the recent clinical research (Fig 2) [61].

11. Future prospects for essential oils

Over the past several years, the market for essential oils has grown significantly, because most of the people showing interest in natural and comprehensive ways to improve overall health and wellbeing. Due to emerging trend of consumers towards essential oils, businesses and entrepreneurs take advantage of this and use several ways to add essential oils and their benefits to their products. Essential oils can be used in a variety of ways because of its benefits including aromatherapy, diffusers, skincare treatments, personal care items, and household cleaners [62]. To improve productivity and quality of essential oil production, research are now using novel approaches or extract essential oils such as microwave assisted extraction, and supercritical fluid extraction. As more studies are conducted in the field of essential oils, it is evident that their effects go far beyond scents and fragrances. These essential oils are the perfect example of how nature may be used to improve health, progress business trends and change environmental behaviors. Their possibilities are limitless, and we are eager to see the exciting developments that lie ahead of us [63].

12. Conclusion

Essential oils affect human beings in several ways. Various studies on these oils have shown that these oils offer a variety of psychological benefits like alleviating depression, lowering anxiety and even helping people to fall asleep. It has been demonstrated that essential oils have antioxidant, antibacterial, antiviral and anti-inflammatory qualities as well are used as natural alternative for artificial insect repellents. Research has shown that some essential oils contain EDCs in their composition which affect the infants directly affecting their breast development who are not yet pubertal. A lot of research has been done on essential oils but there is still great deal to learn about their actual impact on human health.

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