Sonia Malik *Editor*

Essential Oil Research

Trends in Biosynthesis, Analytics, Industrial Applications and Biotechnological Production

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Dedicated To my grandparents

Preface

Essential oils obtained from plants are gaining tremendous attention due to their several biological properties and use in food, cosmetics, and pharmaceutical industries. Essential oils are extracted from various plant parts by using different techniques. The chemical composition and quality of essential oils vary depending on several genetic and environmental factors. By employing diverse biotechnological methods, it is possible to improve the production of essential oils from plants. All these issues have been addressed in this book. Fourteen chapters are written by globally renowned researchers working in the area of essential oils and natural products.

Chapter 1 by Hanif et al. provides the general overview of essential oils, their chemistry, extraction methods, analyses, biological activities, applications, risks, and dangers. The chemical composition of essential oils is influenced by biotic, abiotic, and genetic factors, which are discussed in Chap. 2 by Boaro et al. Chapter 3 by Sakhanokho and Rajasekaran describes the composition and uses of essential oils from different species of *Hedychium*, while the essential oils of family Burseraceae are presented by DeCarlo et al. in Chap. 4. Chapter 5 by Guha and Nandi highlights the potential of essential oil of betel leaf in the world food sector, and Chap. 6 by Desrosiers et al. is focused on essential oils from two different species of *Artemisia.* Activity of essential oils against human oral pathogens has been detailed in Chap. 7 by Marinković et al. Chapter 8 by Blank et al. is devoted on chemical diversity and biological activities of essential oils of plants from Northeast Brazil. Satyal and Setzer discuss about adulteration in essential oils and its analysis in Chap. 9. Applications of essential oils from pines are presented in Chapter 10 by Kumar et al. Segura et al. in Chap. 11 address various biotechnological approaches to improve the yield and quality of essential oil in aromatic plants. The phytochemical composition, pharmacological activities, and biotechnological production of essential oils from geranium are summarized in Chap. 12 by Narnoliya et al. Chap. 13 by Banerjee and Roychoudhury presents the potential applications of metabolic engineering for the enhanced production of aromatic oils in plants. The role of biotechnology in obtaining essential oils from non-herbaceous plants is documented in Chap. 14 by Gounaris. Lastly, Chap. 15 by Semenova et al. aims to describe *Eremothecium* strains as essential oil producers.

Through this multi-authored book, efforts have been made to provide recent developments and techniques for extracting essential oils and various applications of biotechnological methods for their improved production in plants. This book will be a valuable reference for biotechnologists, pharmacists, food technologists, and researchers working in the area of natural plant products and medical and healthcare industries.

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Since the beginning of my task in selecting the title of this book and bringing it into the present form, I have always experienced a special source of inspiration, guidance, and shower of blessings from my grandparents and parents. They have left no stone unturned in shaping my academic career in an exceptional way. I would also like to acknowledge my brothers and their families for their love and affection.

A heartfelt appreciation goes to my husband, Dr. Surender Kumar Sharma, for his valuable advice. I would like to extend my special regards to my mother-in-law and father-in-law for their kind gesture and encouragement.

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Part I
Essential Oils Composition and Why Plants Produce Them

Chapter 1
Essential Oils

Muhammad Asif Hanif, Shafaq Nisar, Ghufrana Samin Khan, Zahid Mushtaq, and Muhammad Zubair

1.1 Introduction

The attraction of aromatic and medicinal plants grows continuously due to the increasing demand as well as interest of consumers in these plants for medicinal, culinary, and other anthropogenic applications. As consumers are increasingly informed about health, food, and nutrition issues, they are also realizing the potential and benefits of aromatic and medicinal plants and their metabolites. There are many secondary metabolites which are produced by these plants; essential oils (EOs) are among them. Composition of essential oils is very complex. Individual components present in essential oils have valuable applications in various fields like agriculture, environment, and human health. Essential oils are found as effective complements to synthetic compounds which are used in the chemical industry. The term essential oil dates back to the sixteenth century and derives from the drug Quinta Essentia, named by Paracelsus von Hohenheim of Switzerland (Brenner 1993). Essential oils (EOs) get their name because of their flammable characteristics. According to French Agency for Normalization: Agence Française

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de Normalisation (AFNOR), essential oils can be defined as (NF T 75-006): "The essential oil is the product obtained from a vegetable raw material, either by steam distillation or by mechanical processes from the epicarp of Citrus, or 'dry' distillation."

EOs are insoluble in inorganic solvents (water) while soluble in organic solvents (ether, alcohol, fixed oils). They are volatile liquids, having a characteristic odor and density less than unity, except vetiver, sassafras, and cinnamon. They are extensively used in perfumery, aromatherapy, and cosmetics industry. Aromatherapy is a therapeutic technique which includes inhalations, massage, or baths by using essential oils (volatile oils). Essential oils (EOs) also serve as chemical signals that allow the plant to control and regulate its environment (ecological role): repel predators, attract insects for pollination, inhibit seed germination, and communicate between different plants. Furthermore, EOs also possesses insecticidal, deterrent, and antifungal activities. Essential oils are present in different parts of aromatic plants such as in flowers (pink, orange, lavender, flower bud in case of clove and bracts in case of ylang-ylang), leaves (in case of mint, eucalyptus, bay leaf, thyme, sage, savory, pine needles), rhizomes (sweet flag and ginger), roots (vetiver), seeds (coriander and carvi), fruits (anise, fennel, and citrus epicarps), and wood and bark (in sandalwood, cinnamon, and rosewood).

1.2 History of Essential Oils

It is challenging to find when first essential oil was extracted; actually ancient writings which tell about the medicinal distilled waters don't exactly describe the procedure used. The very first document describes the distillation process dating back to the ninth century when the Arabs brought essential oils (EOs) into Europe. In the sixteenth century, the concept of essential oils and fatty oils, as well as methods for the separation of essences from the aromatic waters, became well known. At that time, EOs were commercialized with industrial, therapeutic, and cosmetic objectives. By the end of the nineteenth century, chemists managed to isolate, separate, and reproduce the active molecules of essential oils in perfumery, therapy, and other industries.

1.3 Sources of Essential Oils

Leaves		**Peel**	**Flowers**		**Seeds**
Basil	Oregano	Bergamot	Chamomile	Lavender	Almond
Bay leaf	Patchouli	Grape fruit	Clary sage	Manuka	Anise
Cinnamon	Peppermint	Lemon	Clove	Marjoram	Celery
Eucalyptus	Pine	Lime	Geranium	Orange	Cumin
Lemon grass	Rosemary	Orange	Hyssop	Rose	Nutmeg oil

(continued)

Melaleuca	Spearmint	Tangerine	Jasmine	Ylang-ylang	
Wintergreen	Tea tree				
Thyme					
Wood		**Bark**	**Berries**	**Resins**	**Rhizome**
Camphor	Rosewood	Cassia	Allspice	Frankincense	Ginger
Cedar	Sandalwood	Cinnamon	Juniper	Myrrh	

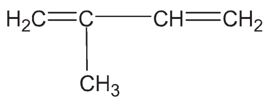
1.4 Chemistry of Essential Oils

There are more than 200 components present in the mixture of pure essential oils. Normally, these mixtures contain phenylpropanic derivatives or terpenes (have minimal structural and chemical differences) (Rao and Pandey 2007). They can be categorized into two classes:

- *Volatile fraction*: Volatile fraction has 90–95% of total oil weight. It contains monoterpenes, sesquiterpenes, and their oxygenated derivatives. Aliphatic alcohols, esters, and aldehydes may also be present in volatile fraction.
- *Nonvolatile residue*: Nonvolatile residue is 1–10% of total essential oil in weight. It contains fatty acids, hydrocarbons, sterols, waxes, flavonoids, and carotenoids.

1.4.1 *Hydrocarbon*

Essential oils contain chemical compounds that have carbon and hydrogen as their building blocks. Isoprene is the major basic hydrocarbon unit found in essential oils. Chemical structure of isoprene is as given below:



1.4.2 *Terpenes*

Terpenes are antiseptic, anti-inflammatory, bactericidal, and antiviral in nature. Terpenes can be classified as sesquiterpenes, monoterpenes, and diterpenes. Two, three, and four isoprene units are joined head to tail and form monoterpenes, sesquiterpene, and diterpenes, respectively. Here are some examples of general monoterpenes: pinene, limonene, camphene, piperine, etc.

1.4.3 Alcohols

Alcohols are antiseptic, antiviral, bactericidal, and germicidal in nature. Naturally, alcohols may present in free form or in combined form with other terpenes or esters. Terpenes along with hydroxyl group are called alcohols. Monoterpene combined with hydroxyl group is called termed as monoterpenol. In the body or skin, alcohols are safe to use as they show very low or completely no toxic reactions. Examples of some common alcohols present in essential oils are as follows: linalool in lavender and ylang-ylang, nerol in neroli, and geraniol in rose and geranium.

1.4.4 Aldehydes

Aldehydes are anti-inflammatory, antifungal, antiseptic, bactericidal, antiviral, sedative, and disinfectant. The presence of aldehydes in essential oils has great medicinal importance as they are effective in the treatment of candida and in many other fungal infections. Examples of some common aldehydes present in essential oils are citral in lemon, citronellal in lemon balm, citrus eucalyptus, and lemongrass.

1.4.5 Acids

Acids are anti-inflammatory in nature. In essential oils, organic acids are present in very small quantity in free form. Plant acids act as components or buffer systems to control acidity. For example, benzoic and cinnamic acids are present in benzoin.

1.4.6 Esters

Esters present in essential oil have soothing and balancing effects. Esters are effective antimicrobial agents due to the presence of alcohol in their structure. In medical field, esters are characterized as sedative and antifungal, with balancing action on nervous system. Some common esters present in essential oils are linalyl acetate in the lavender and bergamot and geranyl formate in the geranium.

1.4.7 Ketones

Ketones are cell proliferant, anti-catarrhal, vulnerary, and expectorant in nature. Essential oils (EOs) have ketones and are considered to be beneficial for promoting wound healing and also for encouraging scar tissue formation. Ketones are generally (not always) toxic in nature. The most toxic ketone is thujone that is found in sage, mugwort, tansy wormwood, and thuja oils. Other toxic ketones found in EOs are pinocamphone in hyssops and pulegone in pennyroyal. Some nontoxic ketones are fenchone in fennel essential oil, jasmone in jasmine essential oil, menthone in peppermint oil, and carvone in spearmint.

1.4.8 Lactones

Lactones are antiphlogistic, anti-inflammatory, febrifuge, and expectorant in nature. Lactones are particularly effective due to their anti-inflammatory action. Lactones have the ability to reduce prostaglandin synthesis and show expectorant actions stronger than that of ketones (Rao and Pandey 2007).

1.5 Methods of Extracting Essential Oils

1.5.1 Maceration

Maceration in fact produces more of "infused oil" rather than that of "essential oil." In this technique, plant material is soaked in the vegetable oil and then heated and strained at a point on which produced product can be used for the massage purpose.

1.5.2 Cold Pressing

Cold pressing is a technique used for the extraction of essential oils from the citrus rinds like lemon, orange, bergamot, and grapefruit. This method encompasses the simple rind pressing followed by the separation of rinds from the fruit, chopping, and then pressing. As a result, a watery mixture is produced that contains both essential oil and liquid present in the source material. These are separated from each other by using appropriate method. It is significant to note that essential oils produced from this method have short shelf life as compared to other methods.

1.5.3 Solvent Extraction

In solvent extraction, essential oil is extracted from plant material using a suitable solvent. Generally, hydrocarbons are added as solvent into the plant material for the extraction of essential oils. After the addition of solvent into the plant material, the produced solution is filtered and then concentrated by the process of distillation. Oil is extracted from the concentrate by the addition of pure alcohol which is then evaporated, and oil is left behind. The main drawback of using this method is that solvent residue left behind may cause allergies and also affect the immune system.

1.5.4 Enfleurage

Enfleurage is the traditional and intensive method for the extraction of essential oils from the flowers. In this process, fat is layered over the flower petal for the extraction purpose. After the absorbance of essential oils by fat from the flower petals, alcohol is used for the separation and extraction of essential oils from fat. At the end of the process, pure essential oil is collected by evaporating the alcohol.

1.5.5 Hydrodistillation

Hydrodistillation has become obsolete for the essential oil extraction process. The use of hydrodistillation in the developed countries is limited due to the production of essential oils with burnt smell. As in this process, material is overheated which causes the burning of aromatic compounds that result in the production of desired product (essential oils) with burnt smell. This process seems to be effective for powders such as groundwood, spice powders, etc. and for tough materials such as nuts, wood, or roots.

1.5.6 CO_2 and Supercritical CO_2 Extraction

This method of extraction is involved in the most modern technologies. Carbon dioxide (CO_2) and supercritical CO_2 extraction processes use CO_2 as "solvent" that carries essential oils away from the desired plant materials. In CO_2 extraction process, CO_2 is used at very high pressure. First of all CO_2 is chilled between temperatures of 35 and 55 °F and then pumped at pressure of 1000 psi through plant material. The carbon dioxide in this condition is condensed to a liquid. In supercritical CO_2 extraction (SCO_2) process, CO_2 is heated at temperature of 87 °F and at pressure of 8000 psi and pumped through plant materials. At these conditions, CO_2 is compared to dense fog or vapor. Pressure of the reaction media is released that results in the removal of carbon dioxide in gaseous form by leaving the essential oil behind. Hence essential oils get separated from the CO_2. Essential oils obtained through this process contain an essence closer to the essence of the original plant material (Reverchon 1997).

1.5.7 Turbo Distillation Extraction

Turbo distillation process is appropriate for the extraction of coarse and hard plant material like roots, seeds, and bark. In this process, plant material is soaked into the water, and then steam is circulated through the plant material and mixture of water. Throughout the process, same water is recycled through the plant material. This method allows essential oil at a faster rate from the hard-to-extract plant materials.

1.5.8 Steam Distillation

Most commonly used technique for the extraction of the essential oil from the plant material is called distillation. In this type of distillation, flowers or plants are placed on screen, and steam passed through the material. Later steam is condensed to produce water and essential oil. At the end, this mixture of essential oil and water is separated (Cassel et al. 2009).

1.6 Analysis of Essential Oils

Qualification and quantification of produced EOs are necessary to ensure its good quality. Different classical as well as modern analytical techniques are used for the analysis of produced EOs.

1.6.1 Classical Analytical Techniques

The earliest analytical techniques used for the examination of essential oils (EOs) were generally focused on the quality aspects that concern only two main properties, i.e., purity and identity (Marques et al. 2009). Titrimetry and gravimetry are classical analytical techniques that are used for the analysis of essential oils (Marques et al. 2009; Guenther 2013). Specific gravity (SG) method is frequently used for the investigation of physicochemical properties of EOs. Furthermore, classical methodologies have been also widely used for the analysis of chemical properties of essential oils (Guenther 2013).

1.6.2 Modern Analytical Techniques

Most of the analytical methods applied for the analysis of EOs are based on the chromatographic procedures that help in the component identification as well as its separation. However, other methods are also required for the confirmation to get reliable identification and avoid equivocated characterization. In the past, researchers were devoted to develop an appropriate method in order to get deeper knowledge regarding the profiles of volatile constituents present in essential oils. However, the complexity of essential oils' structure made this analytical task troublesome. The number of known components present in essential oils has drastically increased with the improvement in instrumental analytical chemistry. In gas chromatographic (GC) analysis, the sample constituents are vaporized and eluted with the help of gas mobile phase while in case of liquid chromatographic (LC) analysis, the constituents of the sample are eluted by liquid mobile phase. In general, the GC is used for the analysis of volatile constituents present in the essential oils, and LC is used for the analysis of nonvolatile constituents present in the essential oils. Chromatography gives both qualitative and quantitative information regarding the analyzed sample (Zellner et al. 2010).

1.7 Biological Activities of Essential Oils

1.7.1 Antibacterial Activity

Essential oils show remarkable antimicrobial properties. Main feature of EOs is their hydrophobicity that allows EOs to partition into lipids of bacterial cell membrane due to which bacterial structure is disrupted and made more permeable (Sikkema et al. 1994). Hence, different ions and many other cellular molecules from the bacterial cell are leaked (Gustafson et al. 1998; Cox et al. 2000; Carson and Riley 1995; Ultee et al. 2002). However, certain amounts of ions and other cellular molecules from the bacterial cells can be endured without any loss of viability, but greater loss of cellular contents and ions can lead to bacterial cell death (Denyer 1991). Commonly, phenolic compounds present in the essential oils like eugenol, thymol, and carvacrol are responsible for the antibacterial activities of essential oils (Dorman and Deans 2000; Knobloch et al. 1986). These compounds can cause coagulation of cell contents and disruption of cytoplasmic membrane/electron flow/driving force of the proton/active transport (Denyer 1991; Pauli 2001).

1.7.2 Antioxidant Activity

Essential oils exhibit excellent antioxidant properties. The antioxidant potential of essential oils depends on the composition of essential oils. Phenolic compounds and other secondary metabolites present in essential oils (containing conjugated double bonds) generally show significant antioxidant properties (Koh et al. 2002). The essential oils obtained from nutmeg, thyme, cinnamon, mint, basil, clove, oregano, and parsley are characterized by most vital antioxidant properties (Aruoma 1998). Most active compounds which show antioxidant properties are carvacrol and thymol. Activity of these compounds is related to their phenolic structure. Due to the redox properties of the phenolic compounds, they play a vital role in neutralization of free radicals and also in decomposition of peroxides (Burt 2004). The antioxidant activity of EOs is also due to other compounds present in essential oils like alcohols, ketones, aldehydes, ethers, and monoterpenes. Common examples of these compounds are linalool, geranial/neral, 1,8-cineole, isomenthone, menthone, citronellal, α-terpinolene, α-terpinene, and β-terpinene (Aruoma 1998).

1.7.3 Anti-Inflammatory Activity

Inflammation is an ordinary protective response which is induced by the infection or any tissue injury and functions to fight with invaders like microorganisms or nonself cells present within the body and to remove damaged or dead host cells. As a result, oxidative burst, release of cytokines, increase in permeability of endothelial lining cells, and incursions of blood leukocytes into interstitium occur. Furthermore, inflammation also stimulates the metabolism of arachidonic acid and the activity of various enzymes (nitric oxide synthases, oxygenases, peroxidases). Essential oils are used as anti-inflammation agents for the treatment of inflammatory diseases like arthritis, allergies, or rheumatism (Maruyama et al. 2005). The active anti-inflammation compounds present in essential oils act as inhibitors for the release of the histamine or reducer for the production of any inflammation mediators. For example, 1,8-cineole—important constituent of many essential oils—acts as an inhibitor for leukotrienes (LTB4) and prostaglandin (PGE2) (Yoon et al. 2000). Anti-inflammatory activities of EOs are not only due to the antioxidant activities of essential oils but also due to the interactions between EOs and signaling cascades (including regulatory transcription factors and cytokines) and due to the expression of the pro-inflammatory genes.

1.7.4 Cancer Chemoprotective Activity

Essential oils show potential activity for the treatment of cancer. Essential oils contain anticancer natural products (Edris 2007) which play a vital role in the prevention and recovery from cancer. There are certain foods like turmeric and garlic which are considered to be good sources of the anticancer agents (Edris 2007). Essential oil obtained from garlic has sulfur compounds like diallyl trisulfide, diallyl sulfide, and diallyl disulfide which show preventive effect against cancer (Milner 2001, 2006).

1.7.5 Cytotoxicity

There are no specific cellular ligands found in essential oils due to their complex chemical composition (Carson and Riley 1995). As lipophilic mixtures, EOs have an ability to degrade cell membrane layers of phospholipids, fatty acids, and polysaccharides. Furthermore, EOs may coagulate cytoplasm (Lambert et al. 2001) and also damage proteins and lipids present in cytoplasm (Ultee et al. 2002; Burt 2004). Damage to the wall and the cell membrane can lead to the leakage of macromolecules and lysis (Turina et al. 2006). Increase in the membrane permeability leads to the death of the cell by the process of necrosis and apoptosis (Oussalah et al. 2006; Novgorodov and Gudz 1996).

1.7.6 Allelopathic Activity

According to the International Allelopathy Society (IAS), allelopathy is defined as "The science that studies any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influences the growth and development of agricultural and biological systems." Allelopathic interactions are derived from the secondary metabolite production by plants and many other microorganisms. The main function of secondary metabolites is to establish a wide range of defense system for plant and microorganisms. The secondary metabolites that show allelopathic activities are termed as allelochemicals (Moon et al. 2006). Bioactive terpenoids are found to have a significant part in defensive mechanisms and also in the agricultural field (Rim and Jee 2006).

1.7.7 Repellent and Insecticidal Activity

Essential oils have various structurally diverse chemical compounds with a variety of repellent and insecticidal mechanisms. There are several factors that affect the commercialization of essential oils. These include biological activity, intellectual property value, product quality, regulatory requirements, and product performance (Ahmed and Eapen 1986). The EOs have toxic effect for both granary insects and flying insects. Eucalyptus (Myrtaceae) and Gaultheria (Ericaceae) oils showed very high toxic effect to kill insects (Mateeva and Karov 1983). Generally, EOs can be ingested, inhaled, or absorbed by the skin of insects. EOs also show fumigant toxicity (Regnault-Roger and Hamraoui 1995). For example, *Anopheles funestus* (Culicidae: Diptera), *Pediculus capitis* (Pediculidae: Anoplura), *Periplaneta orientalis* (Dictyoptera: Blattidae), and *Cimex lectularius* (Cimicidae: Hemiptera) are killed by the use of essential oils obtained from *Eucalyptus saligna* (Myrtaceae) within 2–30 min.

1.8 Applications of Essential Oils

1.8.1 Pharmacology and Medicinal Uses

Essential oils have an important part in the medical field due to their extraordinary medicinal properties. Several EOs show fungicidal, antidepressant, antibacterial, stimulating, and relaxant effect and can be used as an effective therapeutic agent. As essential oils exhibited remarkable therapeutic properties, that is why these oils are used effectively for the treatment of several infections caused by either pathogenic or nonpathogenic diseases. Pathogenic diseases caused by virus, fungi, and bacteria can be treated with the use of respective essential oils. Nonpathogenic diseases are also treated with the appropriate use of essential oils. For example, essential oil obtained from garlic significantly showed lowering in serum cholesterol and triglycerides (TGs) by raising the level of lipoproteins (high density) in patients with coronary heart diseases (Bordia 1981). Some EOs possess hypotensive activity and are used for the treatment of hypertension. EOs and their individual aroma constituents showed anti-cancerous properties and are used in the treatment of breast cancer, tumors, leukemia, glioma, and many others. Sesquiterpene hydrocarbon elements present in EOs in very small amounts are effective for the treatment of glioma (malignant human tumors) (DeAngelis 2001). Antiangiogenic therapy is considered to be one of the most promising methodologies to control cancer.

1.8.2 Uses in Veterinary Medicine

There are various EOs like citronella oil which are used as insecticides or as insect repellents and in veterinary applications. After the ban on the usage of antibiotics in the feed of animals, EOs have emerged as a potential alternative to antibiotics used in the feed of animals. EOs used in veterinary field are categorized into the following classes:

1. Essential oils which attract animals
2. Essential oils which repel animals
3. Antiparasitic, pest repellent, and insecticidal essential oils
4. Essential oils used in the feed of animals
5. Essential oils used for the treatment of animal disease/s

Essential oils are used in the feed of animals as an enhancer for pancreatic and gastric juice production, stimulant for the production of saliva, appetite stimulant, and antioxidant and antimicrobial for the improvement of broiler performance. EOs due to their effective nature should be used in minute quantities in animal nutrition. Otherwise, they can cause reduction in feed intake, accumulation in the animal tissues, and disturbance in gastrointestinal microflora. Taste and odor of EOs may contribute to the refusal of feed by the animals, but encapsulation of EOs is the solution of this problem (Baser and Franz 2010). Generally, essential oils used in the treatment of the human diseases are also recommended for the treatment of animal diseases.

1.8.3 Aromatherapy

For many, the word "aromatherapy" originally became related to the idea of the holistic use of EOs for promoting the health and well-being. With the passage of time, the psychophysiological effects of EOs have been explored continuously. The use of EOs to aid sedation and to reduce anxiety is also discussed in aromatherapy. More significantly, practice of the aromatherapy is firmly related with inhalation of EOs in small doses and their applications to the skin in highly diluted form as a part of aromatherapy massage. Aromatherapy is among the complementary therapies which are used for the treatment of many diseases with the use of EOs as major therapeutic agents. Inhalation, baths, and local applications are the major approaches used in "aromatherapy" that utilize EOs to penetrate into the surface of the human skin with the marked aura. After the entrance of EOs in system, they re-modulated themselves and work in a friendly manner at affected area or at malfunction site. Aromatherapy uses several combinations and permutation to get relief from several ailments like indigestion, depression, insomnia, headache, respiratory problems, muscular pain, urine-associated complications, swollen joints, skin ailments, etc. The use of EOs is found to be more favorable when other facets of life and diet are made due consideration.

1.8.4 Agricultural Uses

Essential oils have a number of applications in sustainable agriculture due to their antibacterial activity against food-spoiling bacteria and food-borne pathogens. EOs are stated to have insecticidal properties basically as larvicidal, ovicidal, antifeedant, repellence, and growth inhibitor (Isman et al. 1990; Regnault-Roger 1997; Dale and Saradamma 1981).

1.8.5 Industrial Uses

The use of essential oils (EOs) at industrial level is a very promising area for the development of any country. The quick development of flavor and fragrance industry in the nineteenth century was largely based on the EOs and related other natural products. In 1876, Haarman and Reimer started to synthesize vanillin (synthetic aroma chemicals) and then anisaldehyde, coumarin, terpineol, and heliotropin.

Even though aroma chemicals made revolution in flavors and fragrances with top discoveries in the twentieth century, for several decades both fragrances and flavors were synthesized with elements of natural origin, nearly all of which were EOs.

1.9 Essential Oil and Health Fitness

Essential oils have the ability to promote wellness when they are used as a part of healthy lifestyle. Independently, EOs have various benefits for human body. When the use of EOs is combined with the physical activities and proper eating manner, they helped the user to feel better overall. The beauty of EOs is that they may be tailored to any type of workout by the alternation in the application methods and EO types to fit the preference and needs of the users. During routine exercise (heavy lifting, dusty hiking trail, intense cardio and recreational sports), EOs can be used to keep the body at peak performance. Essential oils are also a healthy part of weight loss program when their use is combined with the healthy eating and consistent exercise.

1.10 Risks and Dangers of Essential Oils

Essential oils (EOs) have very concentrated properties of the plant or herb from which they are derived. A very small amount of the EOs often have the qualities of several cups of herbal tea from the same plant. As an example, one drop of peppermint EO is comparable to 26–28 cups of the peppermint tea. This is not to say EOs shouldn't be used, but these oils should be utilized with great care and in safe amounts. However, there are several essential oils which are not safe to use internally, and others should really be used with great caution. As EOs are the equivalent to 10–50 cups of herbal tea (depends on the used herb) or 20× the suggested dose of herbal tincture of the exact same herb, they need to only be taken internally in circumstances where they are completely needed and with great care. However, there are many warnings about the safe utilization of EOs. EOs are excellent natural remedies when used in a proper way.

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