Chapter

Essential Oil, Chemical Compositions, and Therapeutic Potential

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Abstract

Essential oils-(EOs) are organic compounds derived from aromatic plant sources such as roots, bark, flowers, leaves and seeds. Essential oils were obtained via two different methods of extraction: steam distillation (SD) and water distillation (WD). EOs-therapy, refers to a range of traditional, alternative or complementary therapies that use essential oils from natural products and other aromatic plant compounds. The chemical components composition of EOs depends on the place of origin, climatic conditions, plant species, plant part extracted, and harvesting time. Essential oils are constituted by diversified bioactive constituents, lipophilic and volatile, and in most cases derivatives of terpene compounds and in lower occurrence phenylpropanoids. They have been long recognized for their medicinal uses: antiviral, antibacterial, insecticidal, antifungal, and antioxidant properties. This chapter provides studies on chemical composition, medicinal uses, and benefits of essential oils.

Keywords: essential oils, methods of extraction, bioactive chemical compositions, therapeutic potential

1. Introduction

Essential oils or vegetable essences are oily, volatile [1], odorous and colorless or slightly tinted products obtained by steam distillation, by expression, by incision or by enfleurage of the plant material [2]. These plant essences are widely distributed in the plant kingdom and exist only in higher plants. Indeed, they are found in appreciable quantity in approximately 2000 species divided into 60 botanical families such as for example in Lamiaceae (lavender, basil, mint ...), Myrtaceae (eucalyptus), Lauraceae (cinnamon and sassafras), and the Apiaceae (coriander, cumin, fennel, parsley..) [3]. Essential oils are found in all the organs of the plant: roots, fruits, seeds, flowers, leaves, bark, wood, etc. They are formed in specialized cells, most often, grouped in channels or in secretory pockets and they are then transported to the different parts of the plant during its growth [4].

They differ from fatty oils, by their physical properties and their composition, because they volatilize on heat and their stains on the paper are transient [5]. They are characterized by their organoleptic properties (smell, color and taste). At room temperature, they are generally liquid with a density often lower than that of water.
They are colorless or pale yellow, with a few exceptions such as the EOs of cinnamon (orange), wormwood (green) or chamomile (blue).

Their refractive index is high and most often they are endowed with rotary power. They are assigned different chemical indices (acid, ester, carbonyl number, etc.).

They are poorly soluble in water and soluble in organic solvents (ether, alcohol, hexane, pentane, etc.) [6]. They dissolve fats, iodine, sulfur, phosphorus and reduce certain salts. In addition, they oxidize and polymerize easily. To avoid this, they should be stored away from light and air.

People are beginning to use EOs widely for a variety of common conditions, and much research shows they may help relieve many disorders and their associated symptoms in some cases. The bioactive compounds in these oils may have several health benefits and actions on the human body and health. Very recent studies showed the use of these oils in many common health conditions such as anxiety, constipation, inflammation, depression and many other disruptions. The following chapter will provide more information on the novel method of extraction of EOs their chemical composition especially the main bioactive compounds, the medicinal uses, and their therapeutic benefits.

2. Methods of extracting essential oils

The extraction of essential oils from plant material can be carried out using many and various processes, based on ancient techniques:

- Distillation, Expression, Enfleurage or Incision or more recent: extraction under microwave or ultrasonic irradiation [6].

- Distillation remains the most popular method because it is easy to implement. Figure 1 shows the different ways of extracting essential oils.

2.1 Distillation

2.1.1 Hydrodistillation

It is the simplest and most widespread technique. It involves immersing the raw material directly in water, then the whole is brought to a boil. The operation is generally carried out at atmospheric pressure. The vapors formed are condensed by a water-flow refrigeration system.

Figure 1.
Methods of extracting essential oils.
During the distillation of EOs, several phenomena are the basis of material exchanges between the solid, liquid and vapor phases, hence the influence of a large number of parameters on the quality and yield of the production of these plant essences [7].

Experiments carried out until the essence of the substrate is exhausted show that the duration of distillation is longer for the organs of woody plants than for herbaceous plants. This difference is strongly linked to the location of the production or storage systems for EOs, which are either on the surface or inside the tissues of the plant. As a result, these structures have an influence on the course of the hydrodistillation, that is to say on the successive mechanisms involved, and therefore on the duration of the extraction operation.

In the event that these structures are superficial, the outer membrane or the cuticle is quickly ruptured upon boiling, the volatile compounds are immediately evaporated. When EOs are subcutaneous, they must first diffuse through the thickness of the plant tissue before coming into contact with water or its vapor so that they can evaporate as in superficial secretions.

2.1.2 Steam training

In this type of distillation, a stream of water vapor passes through the plant which draws out the hydrophobic volatiles. After condensation, the separation takes place by settling. This method improves the quality of the EH by minimizing hydrolytic alterations.

2.1.3 Distillation with organic solvents

Some essential oils have a density close to water and the process by steam distillation cannot be used in this case. The principle consists of macerating the plant in the solvent in order to pass the odorous substances into the solvent.

2.1.3.1 Petroleum based solvents

This method uses organic solvents such as pentane, hexane, heptane, etc. It is reserved for EOs having a density close to that of water.

2.1.3.2 Forane

Forane 113 (F2CCl-CCl2F) extracts a mixture of H.E. and lipid oil at the same time, which makes it possible to double the plant.

2.1.3.3 Carbon dioxide

In liquid or supercritical carbon dioxide extraction, a stream of CO₂ at high pressure burst gasoline pockets [8, 9]. This method is better than hydrodistillation in terms of cost, energy saving, yield and quality of the product obtained because the carbon dioxide is colorless, odorless, non-flammable and non-toxic.

2.2 Microwave or ultrasonic assisted distillation

These recent techniques offer several significant advantages over conventional techniques. In fact, they require a smaller volume of solvent and a reduced heating
time, which prevents the loss and degradation of volatile and heat-sensitive compounds. Thus, they lead to higher returns [6, 10].

2.2.1 Microwave extraction

Microwave extraction involves heating the extractant (water or organic solvent) in contact with the plant under microwave energy which allows for homogeneous heating. This new extraction process saves considerable time and energy [11].

2.2.2 Ultrasonic extraction

The plant material brought into contact with the solvent (water or organic solvent) is immersed in a sonication bath maintained at constant agitation [12].

2.3 Enfleurage

The enfleurage is a rather difficult technique. It dates from ancient Egypt and is based on the strong affinity of odorous molecules for fats. It is mainly reserved for the fragile organs that are the flowers (violet, tuberose, jasmine, ...). These are spread delicately on glass plates coated with a thin layer of grease and these plates are superimposed on wooden frames. Volatile substances diffuse and are absorbed by the fat layer. Then these facts are depleted with alcohol. This process tends to disappear because it requires a large workforce [13].

2.4 Expression

The expression or cold pressing is specific to the extraction of essential oils from citrus fruits: lemons, oranges, mandarins, etc. It is a fairly simple method which consists in mechanically breaking up by abrasion the gasoline pockets located at the level of the peel or pericarp of the fruit to collect its contents [14].

2.5 Incision

It is an infrequent operation. It is enough to split the bark of trees to collect the juice, for example the rubber of the rubber tree.

3. Chemical composition of EOs

The chemical composition of species is complex and can vary depending on the organism, climatic factors, the nature of the soil, cultivation practices and the method of extraction [15]. EOs are a mixture of constituents that belong to three categories of compounds: terpene, aromatic and various.

3.1 Terpenes

Terpenes are hydrocarbons formed by assembling two or more isoprene units. They are polymers of isoprene of the chemical formula (C5H8)n.
Isoprene (2methylbuta-1,3-diene)
Isoprene (2methylbuta-1,3-diene)

Depending on the number of associated units, a distinction is made between:
mono- en (C10); sesqui- en (C15); di- en (C20); tri-en (C30); (C40) tetraterpenes and polyterpenes.

These units can bind to each other by so-called irregular bonds of the artemesyl, santolinyl, lavandulyl and chrysanthemyl type [16].

Essential oils contain particularly monoterpenes, sesquiterpenes and rarely diterpenes [17].

Terpenes have very diverse structures (acyclic, monocyclic, bicyclic, etc.) and contain most of the chemical functions of organic materials. As an indication, some structures of monoterpenes and sesquiterpenes are shown in Figure 2.

3.2 Aromatic compounds

The aromatic compounds are derived from phenylpropane (C6–C3). They are less common than terpenes. This class includes odorous compounds like vanillin, eugenol, anethole, estragole, ... (Figure 3). They are frequently encountered in the EOs of Apiaceae (anise, fennel, parsley, etc.) and are characteristic of those of vanilla, tarragon, basil, cloves, etc. [6]. They differ from each other by:

- The number and position of the hydroxyl and methoxy groups;
- The position of the double bond of the side chain, allylic or propenyl;
- The degree of oxidation of the aliphatic chain (alcohol, aldehyde, ketone or acid, etc).

3.3 Compounds of various origins

In general, low molecular weight compounds of various origins, which can be entrained during hydrodistillation, are straight or branched chain aliphatic hydrocarbons carrying different functions. As an indication, we can quote:
Figure 2. Examples of mono- and sesquiterpene structures.

Figure 3. Examples of structures of compounds derived from phenylpropane.
“The heptane and paraffin in chamomile oil;

• C3 and C10 acids;

• Acyclic esters found especially in fruits: butyl acetate (apple), isoamyl acetate (banana);

• Aldehydes such as octanal and decanal from Citrus;

• Alcohols such as 1-octen-3-ol in lavender oil, ...

4. Properties of essential oils

Essential oils have been used since ancient times for their most diverse therapeutic effects. The molecular diversity of the components they contain gives them very varied roles and biological properties [18].

In fact, monoterpenic hydrocarbons have analgesic properties in percutaneous use, deworming, emmenagogue, atmospheric antiseptic, antiparasitic, etc. Sesquiterpene hydrocarbons have anti-inflammatory, calming, hypotensive effects [19].

The powers offered by the H.Es are innumerable and varied. It would be impossible to mention them all. The demonstration of their biological activity has been the subject of numerous studies [20].

4.1 Role of essential oils in plants

The biological role of H.Es in ecology is obvious. By their smell, they are involved in pollination. Thus, they play an attractive or repellent role with regard to predators (herbivores, insects, etc.) [7]. They can paralyze the masticatory muscles of attackers by the toxic and inappetent properties of the substances they contain [21].

They protect crops by inhibiting the multiplication of bacteria and fungi. They prevent the desiccation of the plant (loss of water) by excessive evaporation and protect the plant against light either by reduction or concentration.

Moreover, their compounds are involved in oxidation–reduction reactions, as hydrogen donors. For example, isoprene reacts rapidly with ozone and hydroxyl radicals. Also, they emit excess carbon and energy [22].

4.2 Biological properties

The spectrum of action of EOs is very wide, as they act against a wide range of bacteria, including those that develop resistance to antibiotics.

In addition, certain essences endowed with antifungal activity oppose the development of fungi and molds by destroying them [23]. These activities also vary from one essential oil to another and from one strain to another [24].

Essential oils act on both Gram-positive and Gram-negative bacteria. However, Gram-negative bacteria appear to be less sensitive to their action and this is directly linked to the structure of their cell wall [25] with some exceptions, such as Aeromonas hydrophila and Campylobacter jejuni, which have been described as particularly sensitive to the action of Essential oils [26]. Nevertheless, Pseudomonas aeruginosa, a Gram-negative bacterium, remains the least active vis-à-vis plant essences.
Aromatic molecules such as phenols followed by aldehydes then ketones then alcohols then ethers have the highest antibacterial coefficient. In general, the action of gasoline takes place in three distinct stages:

- Increase in permeability followed by loss of cellular constituents by attack of the essential oil on the bacterial wall;
- Blocking the production of cellular energy and the synthesis of structural components by acidification of the interior of the cell;
- Death of the bacteria by destruction of its genetic material.

4.3 Medicinal properties

Essential oils have many and varied medicinal properties. Most of the constituents of essential oils have antimicrobial power, hence their use as antiseptics [27]. Others have digestive or antispasmodic, sedative, healing properties, etc. These activities are mainly due to their terpene constituents.

In addition, many EOs exhibit activity against all different types of pain and are widely used to treat inflammatory joint disorders. They have the property of strengthening and reviving the individual's immune defenses [28]. It is in this sense that we could say that aromatic essences were cytophylactic (protective of living cells).

In addition, some EOs have anti-tumor activities and are adopted in the preventive treatment of certain types of cancer (Nigella, Lemon balm) [29].

5. Toxicity of essential oils

EOs are powerful and very active substances. They represent an inexhaustible source of natural remedies. Nevertheless, it is important to emphasize that frequent and excessive self-medication, especially with regard to the dosage as well as the mode of internal or external application by the essences is harmful. It causes more or less harmful side effects in the body (allergies, coma, epilepsy, etc.) mainly in sensitive populations (children, pregnant and breastfeeding women, elderly or allergic people) [30].

The accumulation of essences in the body by repeated intakes can lead to nausea, headaches, etc. Ingestion of more than 10 mL of essential oil is neurotoxic and epileptogenic by inhibiting the supply of oxygen to the level in brain tissue [31].

6. Main fields of application

Due to their various properties, EOs have become a material of considerable economic importance with a constantly growing market. Indeed, they are marketed and are of great interest in various industrial sectors such as pharmaceuticals by their antiseptic, analgesic, antispasmodic, aperitif, anti-diabetic…, in food through their antioxidant activity and flavoring effect, in perfumery and cosmetics through their odoriferous property.
6.1 Aromatherapy

Aromatherapy is a form of alternative medicine in which EOs are of great importance because they induce many curative effects. Thus, they are used more and more in various medical specialties such as: chiropody, acupuncture, massage-physiotherapy, osteopathy, rheumatology as well as in esthetics [4].

6.2 Food industry

By virtue of their antiseptic and flavoring properties, EOs are used daily in culinary preparations (garlic, bay leaf, thyme, etc.). They are also very popular in liquorice (anise drinks, kümmel) and in confectionery (candies, chocolate, etc.). Their antioxidant power allows them to preserve food by avoiding mold, preserving smen for example with thyme and rosemary [32].

6.3 Cosmetology and perfumery

EOs are sought after in the perfume and cosmetics industry because of their odoriferous properties. The perfume industry consumes large tonnages of essences (60%) in particular those of rose, jasmine, violet, verbena, etc. EOs are also consumed in cosmetology to perfume cosmetic products: toothpastes, shampoos, sunscreens, lipsticks, soaps [33]. Hygiene products, detergents and laundry for example, also consume a lot of EO to mask the (often unpleasant) odors of pure products.

6.3.1 Pharmacy

Essences from plants are used largely in the preparation of infusion (mint, verbena, thyme, etc.) and in the form of galenic preparations. More than 40% of medicines are based on active plant components, for example gastralg in is an anti-acid digestive which consists of EO carvi [34].

Likewise, with their flavoring properties, they help mask the unpleasant odor of drugs taken orally. Also, many drugs sold in pharmacies are based on EOs such as eye drops, creams, elixirs [34].

7. Conclusion

The current chapter discusses the diverse chemical bioactive compounds, the multifaceted applications of EOs in the therapeutic approach and develops its exciting potential as a novel green alternative to the toxic effects of synthetic agents. Being naturally used in food with rarely harmful actions and minimal adverse effects, EOs are exempted from toxicity aspects and accepted to be safe for preservation purposes. Also, they represent a considerable economic interest by their applications in the pharmaceutical, agro-food, cosmetological industries.
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References


[20] Bakkali F, Averbeck S, Averbeck D, Idaomar M. Food and Chemical Toxicology. 2008;46:446-475


