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Essential Oils in the Development of New Medicinal Products

Jason Jerry Atoche Medrano

Abstract

The essential oils present a complex composition of different chemical compounds, where they present synergic or complementary action among each other, modifying their activity. Among its main components we can find the terpenoids and phenylpropanoids, which are responsible for giving the medicinal properties. Essential oils generally have a pleasant and intense odor, mostly in liquid form, found in different plant organs and are soluble in polar solvents. Essential oils are volatile, and are widely used in the perfume industry, cosmetics, food and beverage aroma, as well as use in aromatherapy to treat some diseases. The traditional knowledge of some plant species with phytotherapeutic properties is currently a source for research in the search for new biologically active compounds and as effective therapeutics that contemplate current health care.

Keywords: kinds, chemical compounds, productions, medicinal properties, health care

1. Introduction

The essential oils (EOs) have a wide variety in nature with which they turn out to be an important base in the agricultural activity. They can be used as alternative medicine [1], in food products [2], perfume fixatives [3], pharmaceuticals and cosmetics [4], among others. Many types of essential oil oils are obtained from different plant species which means an important production from a commercial point of view, in this way we can conclude that the production and consumption of essential oils are increasing all over the world [5].

The EOs are susceptible to a series of factors that determine the quantity and quality of the same, as well as: the genetic variation, the type or the variety of plants, the geographic location of the plants, the surroundings, the weather, the seasonal variations, stress during growth, the process of obtaining used; affecting its chemical properties, such as composition and phytotherapeutic properties [6, 7].

Essential oils are mixtures of several compounds with low molecular weight; the obtaining can be done through different techniques: steam distillation, hydro distillation or extraction with solvents [8]. Considering the performance for each species should be considered the most convenient technique to be used. Considering commercial scale production, steam distillation is a technique widely used to obtain essential oils [9]. The main components found in the EOs are: monoterpenes, sesquiterpenes and oxygenated derivatives of these. In this way the terpenoids and phenylpropanoids are the components that make up the EOs [10]. Generally, the particular bioactivities of the OEs are due to one or two of the main components, in

this way the characteristics of the EOs is the result of a synergic effect between the main components [11].

We can find from natural products, as well as from their derivatives, new therapeutic sources for various treatments of diseases [12, 13]. Humanity has used natural products since antiquity for the treatment of various diseases, so it is not surprising that this knowledge is sought from a new scientific perspective. Within the natural products we can find the EOs, which have diverse applications mainly in health, agriculture, cosmetics and food.

Currently there is a worldwide effort to study and understand the phytotherapeutic, antimicrobial, antimutagenic, anticancer, antioxidant properties, among others, of the EOs [14].

2. Properties and characterization

The characterization of an essential oil starts with the designation of the vegetable source, i.e., plant, from which it was isolated and the part of the used plant (flowers, leaves, fruits, rhizomes, roots, etc.). It is important to supply, together with the vulgar (vernacular) name of the plant, for example, rosemary, its botanical name (taxonomic identification), which consists of the names of the genus and the species, in this case, *Rosmarinus* (genus) *officinalis* (species) of the Labiatae family and, if the subspecies exists or the variety of the plant, it is important to add it.

It is also necessary to specify, if there is, the chemist of the plant, which receives often its name for the compound majority or distinctive, present in the essential oil. Botanical identification, through the scientific name of the plant, it allows to avoid confusion.

For example, under the vulgar name of “chamomile” they can figure different species, with oils essential composition and properties well different, i.e., German chamomile is *Matricaria recutita* (*Matricaria chamomilla*) and the Roman chamomile is *Anthemis nobilis*; both belong to the family Asteraceae (Compositae) and both are commonly called “chamomile.” Along with identification botany, the provenance of the plant, that is, where it was cultivated (country, region) and what was the extraction method of its essential oil (steam drag or hydrodilataion).

Many factors affect the composition and yield of essential oil in the plant. Among the main ones are: geoclimatic localization, type of soil, stage of development of the plant (e.g., before, during or after flowering) and even the time of day when it is harvested, among others. Geoclimatic factors and soil type can give rise to different chemotypes of the plant, from which essential oils with chemical composition, sensory properties and different biological activity are distilled. For example, in thyme, *Thymus vulgaris* (Fam. Labiatae), at least four chemists are distinguished, according to their major compounds in the essential oil: (I) thymol and p-cymene; (II) carvacrol, timol and borneol; (III) linalool, terpinen-4-ol and linalyl acetate and (IV) geraniol and geranyl acetate. Each oil isolated from these chemotypes, smells different and has different biological properties.

While thymus chemotypes I and II have a strong antibacterial activity, they are irritant, chemotypes III and IV are not and have a moderate antibacterial activity. Thyme chemotype III oil has a sedative effect due to the presence of linalool, monoterpene alcohol, and its acetate [15].

Another example, is the essential oils of geranium plants (*Pelargonium graveolens*), cultivated in the Reunion Islands (Indian Ocean, northern Madagascar) and in China. In the international market the first essential oil is known as “Bourbon” and the second is called “Chinese geranium oil”; its chemical compositions vary widely [15], which can be seen in **Table 1**.

Compounds	Geranium (China), %	Geranium (reunion), %
Citronellol	40	22
Citronellyl formate	11	8
Geraniol	6	17
Geranyl formate	2	7.5
Linalool	4	13

Table 1.
Comparison of essential oils, according to their major compounds isolated from geraniums cultivated in China and Reunion Islands.

Another important parameter is the time of harvest of the plant; from this depend both the yield and the composition of the extracted oil [16]. For example, sage essential oil (*Salvia officinalis*, Fam. Labiatae) contains a neurotoxic monoterpene ketone, α -thujone [15], in different amounts, depending on the time when the plant is harvested. The content of the ketone varies as follows: it is high, when the plant is harvested after flowering, and it is low before its flowering. This is precisely the time when the collection of *Salvia officinalis* is done.

The jasmine flowers collected in the morning hours contain in their oil a preferred combination of linalool, benzyl alcohol, cis-jasmone and indole, but when the flowers are collected in the afternoon hours, their oils have high levels of benzyl benzoate, eugenol and methyl salicylate; the last two introduce some unpleasant and undesirable scent notes, which can generate a rejection in the perfume industry or in aromatherapy. For ylang-ylang (*Cananga odorata*, Fam. Anonáceae), the state of its flowers, i.e., fresh vs. wilted, or ripe, yellow vs. green and underdeveloped, notably affects the composition of the oil obtained: the Extra quality of the oil is reached, among other factors, when the yellow flowers are exclusively distilled, completely developed, freshly collected during the first hours of the morning [17].

3. Essential oils used against bacteria and microbes

It is a fact that many of the bacterial infections have increased even after the discovery of many antibiotics, among other factors due to the appearance of strains resistant to antibiotics and the increase of the population with less immunity. This being one of the main causes of deaths due to infectious diseases caused by bacteria [18]. Additionally, the effects of toxicity due to side effects restrict the prolonged use of high concentrations of available antibacterial drugs. In this way it is evident the need to explore new molecules and alternative treatments against pathogenic bacteria, obtained from these natural products [19].

Many plant species contain molecules with antimicrobial properties. It has been shown that especially plant OEs exhibit broad-spectrum inhibitory activities against various bacterial pathogens [20]. In the case of the family of grasses, Poaceae, which includes the producer of lemongrass oil (of *Cymbopogon citratus*), citronella oil (of *C. nardus*) and palmarosa oils (*C. martinii*). The medicinally active components of these EOs are citral, geraniol and geranyl acetate. They have demonstrated antimicrobial and anticancer properties.

In the case of citrus oils that constitute limonene and linalool are derived from the fruit peel of the plants belonging to the Rutaceae family, it has been shown that these components exhibit antimicrobial potential. In the case of the plants *Pelargonium graveolens* and *Santalum* spp. of the family Geraniaceae and Santalaceae, respectively, it has been determined that they possess two important oils, namely, geranium oil and sandalwood, with similar properties [21].

4. Antifungal activities of essential oils

Considering the case of fungi (eukaryotes), they have similarities with their guests both at a cellular and molecular level. Therefore, fungi are a difficult target to attack [22]. Currently there is evidence of the emergence of drug-resistant strains, infections associated with biofilms and the side effects of prescription drugs present difficulties for the prevention and treatment of fungal infections.

Therefore, invasive fungal infections are associated with very high morbidity and mortality rates [23]. Studies have been reported where various fungal pathogens of plants and humans, including yeasts, have been found to be susceptible to EOs [24]. There is evidence that pathogenic yeasts sensitive to drugs, as well as resistant ones, including the main pathogen of humans, *C. albicans*, were inhibited using terpenoid-rich EOs [25].

The efficiency using EOs and their components against the biofilms of *C. albicans* resistant to drugs is important. These activities can be mediated through the inhibition of the ergosterol membrane and the signaling pathways involved in the morphogenesis of the hyphae [26].

5. Cancer preventive properties using essential oils

The treatment in malignant cells represents a challenge for current medicine; In this sense, many plants with phytotherapeutic properties (such as taxol) have shown their efficiency as an alternative method in combating and proliferating malignant cells that can lead to cancer such as: colon cancer, gastric cancer, human liver tumor, lung tumors, breast cancer and leukemia, which have reported a decrease after treatment with OEs [27].

For example, there is evidence that *Cymbopogon martini* geraniol (i.e., palmarosa oil) manages to interfere with membrane functions, ionic homeostasis, and cell signaling events in cancer cell lines, which inhibits synthesis of DNA and a subsequent reduction in the size of the colon tumor [28].

In the case of terpenoids and constituent polyphenols, obtained from plant EOs, they can prevent the proliferation of tumor cells by necrosis or induction of apoptosis [29].

Citral present in lemongrass oil is found useful against the early phase hepatocarcinogenesis [30]. Another example, well known for its anticancer properties is the use of EO from *Allium sativum* (garlic). The preventive activity of chemotherapy is limited to the ability of garlic to suppress detoxifying enzymes of drugs [31]. Additionally the use of EO of lemon balm (*M. officinalis*) inhibits the growth of a series of human cancer cell lines [32].

In this way, it is well established that OEs exhibit a capacity to act as antioxidants and interfere with the mitochondrial functions of cells, decreasing metabolic events (for example, increased cellular metabolism, mitochondrial overproduction and permanent oxidative stress) characteristic of the development of malignant tumors [33].

6. Antiviral efficacy of essential oils

In addition to the aforementioned antimicrobial activities, there are plants that have significant antiviral properties, for example: *Origanum vulgare* anti-viral inactivation of enteric virus [34]; *Eucalyptus globulus* (Eucalyptus oil) activity against respiratory viruses [35]; *Salvia fruticosa*, antiviral activities [36], among

other. It is believed that the inhibition of viral replication is attributed to the presence of the monoterpene, sesquiterpene and phenylpropanoid components of the EOs [37].

EOs of eucalyptus and thyme possess inhibitory activity against the herpes virus [38]. Evidence has been found that OEs of *Melaleuca alternifolia* showed significant efficacy in the treatment of herpes virus [39]. The way in which the adsorption or entry of virus into host cells is prevented is associated with the ability to interfere with the viral envelope structures. For example, oregano oil causes dissolution of the HSV envelope to attenuate its infectious capacity [40]. There is evidence that the components of EOs specifically inhibit the early expression of the gene in CMV (cytomegalovirus) and thus prevent viral activation [41].

7. Essential oils as antioxidants

A cause of damage suffered by macromolecules is due to the oxidative stress that is associated with the generation of free radicals and reactive oxygen species (ROS) [42]. Published works show that oxidative damage is related to several health problems such as aging, arteriosclerosis, cancer, Alzheimer's disease, Parkinson's disease, diabetes and asthma [43].

Cellular balance of free radicals is maintained by different antioxidants. Flavonoids, terpenoids and phenolic constituents of EOs exhibit significant antioxidant effects [44]. There is evidence that species, such as: *Origanum majorana*, *Tagetes filifolia*, *Bacopa monnieri* and *C. longa* oils have pronounced antioxidant capacities [45]. In general, efficiency among the essential oils with good radical and antioxidant removal properties are made to order. We can mention species such as: cloves > cinnamon > nutmeg > basil > oregano > thyme [46].

8. Obtaining essential oils

Essential oils can be obtained from plant material by three main methods [47] view **Figure 1**.

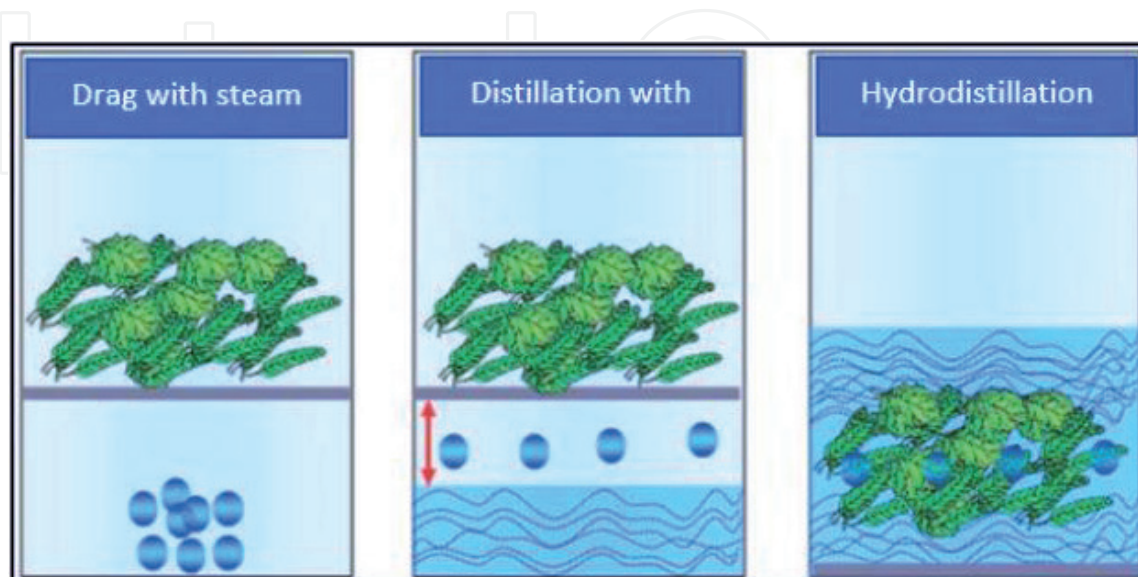


Figure 1. Obtaining essential oils by entrainment with steam (external source of steam, e.g., boiler); distillation with water vapor (wet steam obtained by heating the water to its vigorous boiling); and hydrodistillation (heating of the water with the submerged plant material, generally very delicate, for example, flowers).

8.1 Drag with steam

This process is carried out with an overheated dry steam, usually generated by a boiler or boiler, which penetrates the plant material under pressure higher than atmospheric, the vapor stream breaks the oil cells or channels in the plant and entrains the volatile mixture, which condenses after passing through a refrigerant. Generally the oils are lighter than the water and very little soluble in it; therefore, can be separated by decantation. The exception is nail oil, which is heavier than water and is collected underneath it. The steam entrainment method is used to extract rhizome oils, roots, seeds (vetiver, valerian, ginger, anise, cardamom, etc.) and dried or fermented leaves of some plants (e.g., patchouli).

8.2 Distillation with water vapor

In this system of extraction uses a humid steam, coming from the water in boiling, that transpasses the vegetal material suspended above and supported on a mesh. Most herbaceous plants are distilled by this method.

8.3 Hydrodistillation

Hydrodistillation is a process when the plant material is submerged directly into the water, which is heated to boil. This method is used for the distillation of the plant material delicate, for example, flowers (e.g., ylang-ylang, roses).

9. Classification of essential oils

We can classify essential oils based on the following criteria: consistency, origin, and chemical nature of the major components.

9.1 Consistency

For its consistency the essences are divided into: fluid essences, balms and oleoresins.

- a. The fluid essences, they are very volatile liquids at room temperature (essences of rosemary, mint, sage, lemon, basil).
- b. The balms, they are thicker, less volatile, contain mainly sesquiterpenoids and are prone to polymerize (balms of Copaiba, balsam of Peru, balsam of Tolu, storax, etc.).
- c. The oleoresins, they have the aroma of the plants in a concentrated form, they are typically very viscous liquids or semi-solid substances (rubber, gutta-percha, chewing gum, oleoresins) of paprika, of black pepper, of clavero, etc.)

9.2 Origin

Regarding the origin, essential oils are classified as: natural, artificial and synthetic.

The natural EOs are obtained directly from the plant and are not subsequently subjected to any physicochemical or chemical modification, they are expensive and

varied in composition. The artificial essences are obtained by enrichment of natural essences with one of its components; they are also prepared by mixtures of several natural essences extracted from different plants as a mixture of essences of rose, geranium and jasmine.

The essence of anise enriched with anethole is an artificial essence. The synthetic essences are mixtures of various products obtained by chemical processes. They are more economical and therefore are widely used in the preparation of substances flavors and flavorings, such as essences of vanilla, lemon, and strawberry.

9.3 Chemical composition

Essential oils differ in composition and properties of fatty acids or fixed oils, which are composed of glycerides; and of mineral oils that are composed of hydrocarbons.

Because essential oils are a part of the metabolism of plants, their chemical composition varies permanently, modifying the proportions of their constituents or transforming one another, according to the part of the plant the moment of its development or the time of day when collect the plant.

The proportion of the components of the mixture varies from one oil to another, that is, each essential oil has its own characteristic mixture of compounds with defined qualitative and quantitative variations. Some may be so simple as cinnamon oil formed in 85% of cinnamaldehyde only, or as complex as jasmine, or chamomile oil with about 130 compounds. A discrimination is made between the compounds contained in an essence, and then we speak of major compounds when the compounds are present in the essence in a proportion >1 or 0.5%.

An essence is in permanent change, not only while it is part of the metabolism of the plant, also after it is extracted; this speaks of a reduced stability and a process of continuous transformation, which generates three stages in the life of an essence: that of maturation or aging, that of stability or useful life and that of decomposition or rancidity, each essence has different times for each stage, including depending on the case, the intermediate stage, where it is considered that the changes do not significantly change the quality of the same, may have a positive or negative trend.

It must be taken into account that given its complex composition, essences have a high probability of undergoing physicochemical modifications by reactions between its own constituents or between these and the medium that includes factors such as: light, temperature, presence of enzymes, the components of the part of the plant where the essence is stored, etc.

10. Conclusions

At present, there is a growing demand to explore the vast variety of plant species with biological activities, and their EOs with therapeutic potentials that can help in the alternative treatment of different diseases. But there is also a need to increase awareness of the risks and benefits associated with the medicinal uses of EOs, which is still a matter of research.

Use of plant molecules to treat, for example, infectious diseases is a complementary alternative. The use of EOs in the treatment of malignancy, artemisinin (isolated from *Artemisia annua*) and the anticancer drug, taxol (from *Taxus brevifolia*) are successful examples of the use of these popular medicines, obtained from these plant species at a cost much smaller than conventional medications.

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Conflict of interest

We mentioned that we have no conflict of interests.

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References

- [1] Ngom S, Perez RC, Mbow MA, Fall R, Niassy S, Cosoveanu A, et al. Larvicidal activity of neem oil and three plant essential oils from Senegal against *Chrysodeixis chalcites* (Esper, 1789). *Asian Pacific Journal of Tropical Biomedicine*. 2018;**8**(1):67
- [2] Ju J, Xu X, Xie Y, Guo Y, Cheng Y, Qian H, et al. Inhibitory effects of cinnamon and clove essential oils on mold growth on baked foods. *Food Chemistry*. 2018;**240**:850-855
- [3] Nour AH. Formulation of solid/liquid perfumes of essential oils from different medicinal. *Plants*. 2018;**5**:95-115
- [4] Sarkic A, Stappen I. Essential oils and their single compounds in cosmetics—A critical review. *Cosmetics*. 2018;**5**(1):11
- [5] Djilani A, Dicko A. The Therapeutic Benefits of Essential Oils. *Nutrition, Well-Being and Health*. InTech; 2012. DOI: 10.5772/25344
- [6] Rguez S, Msaada K, Daami-Remadi M, Chayeb I, Bettaieb Rebey I, Hammami M, et al. Chemical composition and biological activities of essential oils of *Salvia officinalis* aerial parts as affected by diurnal variations. *Plant Biosystems-An International Journal Dealing with all Aspects of Plant Biology*. 2018;**153**:1-9
- [7] Askary M, Behdani MA, Parsa S, Mahmoodi S, Jamialahmadi M. Water stress and manure application affect the quantity and quality of essential oil of *Thymus daenensis* and *Thymus vulgaris*. *Industrial Crops and Products*. 2018;**111**:336-344
- [8] Giacometti J, Kovačević DB, Putnik P, Gabrić D, Bilušić T, Krešić G, et al. Extraction of bioactive compounds and essential oils from mediterranean herbs by conventional and green innovative techniques: A review. *Foodservice Research International*. 2018;**113**:245-262
- [9] Pateiro M, Barba FJ, Domínguez R, Sant'Ana AS, Khaneghah AM, Gavahian M, et al. Essential oils as natural additives to prevent oxidation reactions in meat and meat products: A review. *Foodservice Research International*. 2018;**113**:156-166
- [10] Carson C, Hammer K, Riley T. *Melaleuca alternifolia* (tea tree) oil: A review of antimicrobial and other medicinal properties. *Clinical Microbiology Reviews*. 2006;**19**(1):50-62
- [11] Bakkali F, Averbeck S, Averbeck D, Idaomar M. Biological effects of essential oils—A review. *Food and Chemical Toxicology*. 2008;**46**(2):446-475
- [12] Parvez MK. Natural or plant products for the treatment of neurological disorders: Current knowledge. *Current Drug Metabolism*. 2018;**19**(5):424-428
- [13] Raghunath A, Sundarraj K, Kanagaraj VV, Perumal E. 9 plant sources as potential therapeutics for Alzheimer's disease. In: *Medicinal Plants: Promising Future for Health and New Drugs*. Parimelazhagan Thangaraj Editorial; 2018. p. 161
- [14] Sathya B, Balamurugan K, Anbazhagan S. Bioactive compounds with neuropharmacological properties from medicinal plants—A brief review. *World Journal of Pharmacy and Pharmaceutical Sciences*. 2018;**7**:368-388
- [15] Czapak MP. Os Recursos Vegetais aromáticos no Brasil: Seu Aproveitamento Industrial Para a produção de Aromas e Sabores. Editorial

da Universidade Federal do Espírito Santo; 2008

[16] Maia J. Plantas aromáticas da região Amazônica. Os recursos vegetais aromáticos no Brasil: Seu aproveitamento industrial para a produção de aromas e sabores. 2008

[17] Pino B, Ramírez G. Traditional knowledge of vegetable species used with magic-religious purpose in communities of the northern Colombian Pacific. *Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas*. 2009;8(3):180-183

[18] Felden B, Cattoir V. Bacterial adaptation to antibiotics through regulatory RNAs. *Antimicrobial Agents and Chemotherapy*. 2018;62:02503-02517

[19] Iseppi R, Sabia C, de Niederhäusern S, Pellati F, Benvenuti S, Tardugno R, et al. Antibacterial activity of *Rosmarinus officinalis* L. and *Thymus vulgaris* L. essential oils and their combination against food-borne pathogens and spoilage bacteria in ready-to-eat vegetables. *Natural Product Research*. 2018;33:1-5

[20] Lang G, Buchbauer G. A review on recent research results (2008-2010) on essential oils as antimicrobials and antifungals. *A Review Flavour and Fragrance Journal*. 2012;27(1):13-39

[21] Bedi S, Vyas S. *A Handbook of Aromatic and Essential Oil Plants: Cultivation, Chemistry, Processing and Uses*. Jodhpur: Agrobios Editorial; 2008

[22] Routh MM, Raut JS, Karuppayil SM. Dual properties of anticancer agents: An exploratory study on the in vitro anti-Candida properties of thirty drugs. *Chemotherapy*. 2011;57(5):372-380

[23] Sardi J, Scorzoni L, Bernardi T, Fusco-Almeida A, Giannini MM. *Candida* species: Current epidemiology,

pathogenicity, biofilm formation, natural antifungal products and new therapeutic options. *Journal of Medical Microbiology*. 2013;62(1):10-24

[24] Galvão LCC, Furletti VF, Bersan SMF, da Cunha MG, Ruiz ALTG, Carvalho JE, et al. Antimicrobial activity of essential oils against *Streptococcus mutans* and their antiproliferative effects. *Evidence-based Complementary and Alternative Medicine*. 2012;12:1-12

[25] Zore GB, Thakre AD, Rathod V, Karuppayil SM. Evaluation of anti-Candida potential of geranium oil constituents against clinical isolates of *Candida albicans* differentially sensitive to fluconazole: Inhibition of growth, dimorphism and sensitization. *Mycoses*. 2011;54(4):e99-e109

[26] Raut JS, Shinde RB, Chauhan NM, Mohan Karuppayil S. Terpenoids of plant origin inhibit morphogenesis, adhesion, and biofilm formation by *Candida albicans*. *Biofouling*. 2013;29(1):87-96

[27] Hamid A, Aiyelaagbe O, Usman L. Essential oils: Its medicinal and pharmacological uses. *International Journal of Current Research*. 2011;33(2):86-98

[28] Qi F, Yan Q, Zheng Z, Liu J, Chen Y, Zhang G. Geraniol and geranyl acetate induce potent anticancer effects in colon cancer Colo-205 cells by inducing apoptosis, DNA damage and cell cycle arrest. *Journal of BU ON: Official Journal of the Balkan Union of Oncology*. 2018;23(2):346-352

[29] Raut JS, Karuppayil SM. Bioprospecting of plant essential oils for medicinal uses. In: Fulekar MH, Bhawana Pathak, Kale RK, editors. *Environment and Sustainable Development*. Springer; 2014. pp. 59-76

- [30] MacHraoui M, Kthiri Z, JABEUR M, Hamada W. Ethnobotanical and phytopharmacological notes on *Cymbopogon citratus* (DC.) Stapf. Journal of New Sciences. 2018;55:3642-3652
- [31] Alam MK, Hoq MO, Uddin MS. Medicinal plant *Allium sativum*. A review. Journal of Medicinal Plant Studies. 2016;4(6):72-79
- [32] Magalhães DB, Castro I, Pereira JM, Lopes-Rodrigues V, Ferreira IC, Xavier C, et al. Study of the mechanism of action of *Melissa officinalis* L. extracts in inhibiting the growth of human tumor cellular lines. IUJUP. 2018;9:3134-3142
- [33] Ali B, Al-Wabel NA, Shams S, Ahamad A, Khan SA, Anwar F. Essential oils used in aromatherapy: A systemic review. Asian Pacific Journal of Tropical Biomedicine. 2015;5(8):601-611
- [34] Sánchez G, Aznar R. Evaluation of natural compounds of plant origin for inactivation of enteric viruses. Food and Environmental Virology. 2015;7(2):183-187
- [35] Horváth G, Ács K. Essential oils in the treatment of respiratory tract diseases highlighting their role in bacterial infections and their anti-inflammatory action: A review. Flavour and Fragrance Journal. 2015;30(5):331-341
- [36] Miraj S, Kiani S. A review study of therapeutic effects of *Salvia officinalis* L. Der Pharmacia Lettre. 2016;8(6):299-303
- [37] Astani A, Reichling J, Schnitzler P. Screening for antiviral activities of isolated compounds from essential oils. Evidence-based Complementary and Alternative Medicine. 2011;11:1-8
- [38] Koch C, Reichling J, Schnee J, Schnitzler P. Inhibitory effect of essential oils against herpes simplex virus type 2. Phytomedicine. 2008;15(1-2):71-78
- [39] Astani A, Schnitzler P. Antiviral activity of monoterpenes beta-pinene and limonene against herpes simplex virus in vitro. Iranian Journal of Microbiology. 2014;6(3):149
- [40] Akthar MS, Degaga B, Azam T. Antimicrobial activity of essential oils extracted from medicinal plants against the pathogenic microorganisms: A review. Issues in Biological Sciences and Pharmaceutical Research. 2014;2(1):1-7
- [41] Pusztai R, Abrantes M, Sherly J, Duarte N, Molnar J, Ferreira M-JU. Antitumor-promoting activity of lignans: Inhibition of human cytomegalovirus IE gene expression. Anticancer Research. 2010;30(2):451-454
- [42] Bhattacharya S. Reactive oxygen species and cellular defense system. In: Rani V, Chand U, Yadav S, editors. Free Radicals in Human Health and Disease. Springer. 2015. pp. 17-29
- [43] Kehrer JP, Klotz L-O. Free radicals and related reactive species as mediators of tissue injury and disease: Implications for health. Critical Reviews in Toxicology. 2015;45(9):765-798
- [44] Sánchez-Vioque R, Polissiou M, Astraka K, De Los Mozos-Pascual M, Tarantilis P, Herraiz-Peñalver D, et al. Polyphenol composition and antioxidant and metal chelating activities of the solid residues from the essential oil industry. Industrial Crops and Products. 2013;49:150-159
- [45] Erenler R, Sen O, Aksit H, Demirtas I, Yaglioglu AS, Elmastas M, et al. Isolation and identification of chemical constituents from *Origanum majorana* and investigation of antiproliferative and antioxidant activities. Journal of

the Science of Food and Agriculture.
2016;**96**(3):822-836

[46] Asprea M, Leto I, Bergonzi MC, Bilia AR. Thyme essential oil loaded in nanocochleates: Encapsulation efficiency, in vitro release study and antioxidant activity. LWT-Food Science and Technology. 2017;**77**:497-502

[47] Guzmán JD. Fragmentación diastereoespecífica de los lignanos dibencilbutánicos de la corteza de *Dugandiodendron argyrotichum* (Magnoliaceae). Revista Productos Naturales. 2008;**2**(1):6-12