The PLANTA RBS: Vol.-2 Issue-2, (October) 2021: 830 - 849
(Research Book Series – www.pgrindias.in)

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EXTRACTION OF ESSENTIAL OIL FROM VARIOUS PLANTS AND THEIR ANTIMICROBIAL ACTIVITY[#]

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Abstract

Scientists have shown that methods such as hydro distillation, solvent-extraction, Soxhlet extraction, cold-pressing method developed for extraction of valuable components from plants have been successfully used. Essential oils are complex volatile compounds, naturally synthesized by various parts of the plant during the secondary metabolism of plants. A wide range plants having the medicinal properties have been explored and used for the extraction of oils worldwide due to their antimicrobial properties against the bacterial, fungal and viral pathogens. The presence of a large number of alkaloids, phenols, terpenes derivatives compounds and other antimicrobial compounds makes the oils more précised in their mode action against the ample variety of pathogenic microorganisms. Thus, the essential oils could be used as better supplements or chemical components or medicinal drug or alternatives against the pathogenic microorganisms.

Key Words: Extraction, Essential oils (EOs), Distillation, Antimicrobial activity

[#]General Article

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Introduction

There are many plants have the ability to inhibit the growth of pathogenic microorganisms due to presence of essential oils. Many plant-oils have been extracted from complex mixture of volatile molecules produced by the secondary metabolism of plants. Secondary metabolism produces a large number of specialized compounds that do not aid in the growth and development of plants but are required for the plant to survive in its environment. Primary metabolism governs all basic physiological processes that allow a plant to grow and set seeds, by translating the genetic code into proteins, carbohydrates, and amino acids. Specialized compounds from secondary metabolism are essential for communicating with other organisms in mutualistic (e.g. attraction of beneficial organisms such as pollinators) or antagonistic interactions (e.g. deterrent against herbivores and pathogens). Some of the plants have ability to produce essential oils or chemical compounds from it and shown the antimicrobial effect against pathogens. Essential oils are natural, volatile liquid, complex compounds characterized by a strong odor, rarely colored, soluble in lipid and organic solvents. Essential oils can be extracted from all plants or different parts of the plant like bark, leaves, roots, wood, seeds or fruits, flowers, burgeons, branches. Essential oils are plant-based volatile oils with strong aromatic components that are made up of different chemical compounds. For example, alcohols, hydrocarbons, phenols, aldehydes, esters and ketones are some of the major components of essential oil. Essential oils generally have 2-3 major components at fairly high concentrations (20-70%) compared to other components present in trace amount. For example, Carvacrol (30%) and thymol (27%) are the main components of the Origanum compactum essential oil (Betts, 2001). The majority of essential oils are composed of terpenes and terpenoids and other aromatic and aliphatic constituents, all characterized by low molecular weight. Terpenes are the major group of plant natural products characterized by an extensive variety of structural types and the most valuable compounds (Degenhardt et al., 2009). The terpene compounds are hydrocarbons of general formula $(C_5H_8)_n$ formed from isoprene units. The chemical profile of essential oils varies in the number of molecules, stereochemical properties of molecules, and also depends on the type of extraction.

The extraction products may vary in quality, quantity and in composition according to climate, soil composition, plant organ, age and vegetative cycle stage (Masotti et al., 2003; Angioni et al., 2006). Essential oils or some of their constituents are indeed effective against a large variety of organisms including bacteria and viruses (Duschatzky et al., 2005), fungi (Hammer et al., 2002) and protozoa (Monzote et al., 2006). The essential oils are known for their bactericidal, virucidal, fungicidal activity due to their medicinal properties against the wide range of pathogenic microorganisms. Use of synthetic chemicals for the control of pathogenic microorganisms is limited because of their carcinogenic effect, acute toxicity and environmental hazards. The use of essential oils to combat with the infectious microorganisms and to control epidemic multi-drug resistant microorganisms is the promising approach (Mulyaningsih et al., 2010).

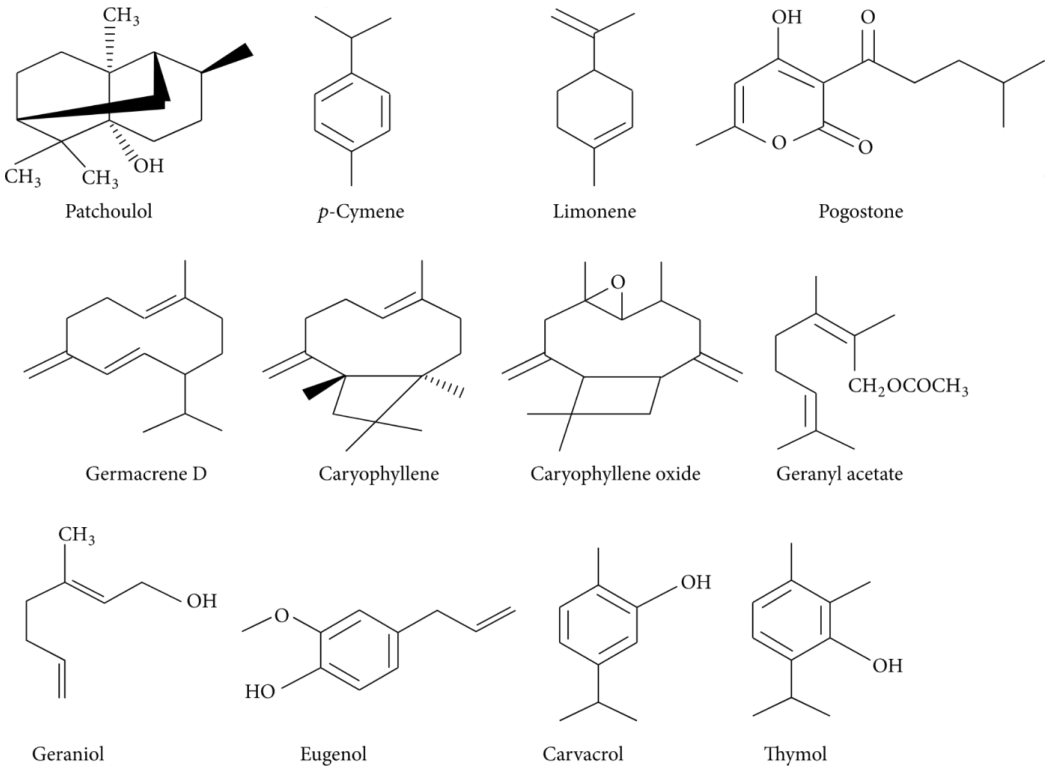

Figure 1: Structures of the Plant-oil's chemical components. A) Patchoulol; B) p-cymene; C) Limonene; D) Pogostone; E) Germacrene D; F) Caryophyliene; G) Caryophyliene; H) Geranyl acetate; I) Geraniol; J) Eugenol; K) Carvacrol; L) Thymol.

Antimicrobial Activity of Essential Oils

Various types of essential oils have been used in various types of medicinal applications because of their antimicrobial activity. The antimicrobial activity of plant-derived essential oils is the basis of many applications, especially in food preservation, aromatherapy, medicinal and so on. Cowan (1999) reported that approximately 3,000 essential oils are currently known so far. Out of which 300 are of commercially important and widely used in the pharmaceutical, agronomic, food, sanitary, cosmetic and perfume industries (Hajhashemi et al., 2003; Perry et al., 2003).

Table 1: Effect of some Plant-oils on the Pathogenic microorganisms

Plant source	Chemical compound	Inhibited organisms
Thymus vulgaris (Arial part)	Thymol, Linalol, Carvacrol	*L. monocytogens,* *E. coli,* *S. typhimirium,* *S. aureus*
Origanum vulgare (Arial part)	Carvacrol, Thymol, γ-Terpinene	*L. monocytogens,* *E. coli,* *Adeno virus,* *Polio virus*
Cymbopogon (Fruit)	Ethanolic compounds	*Enteriobacteriacae,* *S. aureus*
Allium sativum (Bulb)	Isothiocynate	*Enteriobacteriacae,* *Candida spp.*
Syzygium Aromaticum (Flower bud)	Eugenol, Eugenylacetate	*Eneriobactericae,* *A. fumigatus,* *Candida spp.,*
Zingiber officinale (Rhizomes)	Ethanolic compounds	*Adeno virus,* *Polio virus* *Enteriobacteriacae*

Antibacterial Actions of Essential Oils

Conner (1993) found that cinnamon, clove, pimento, thyme, oregano, and rosemary plants has inhibitory effect on some of the pathogenic organism. It has been found that oils extracted from some plants had the antibacterial effects against all food borne pathogens due to presence of phenolic compounds such as carvacrol, eugenol and thymol (Kim et al., 1995). However, Ramos-Nino et al., (1996) found that benzoic acids, benzaldehydes and cinnamic acid were able to inhibit the growth of Listeria monocytogenes. Similarly, Ouattara et al.,(1997) observed the antibacterial activity of selected spices on the meat spoilage bacteria. Arora and Kaur (1999) analyzed the antimicrobial activity of garlic, ginger, clove, black pepper and green chilli on the human pathogenic bacteria viz. Bacillus sphaericus, Enterobacter aerogenes, E. coli, P. aeruginosa, S. aureus, S. epidermidis, S. typhi and Shiguella flexneri and stated that amongst all the tested spices, aqueous garlic extracts was sensitive against all the bacterial pathogens. Similarly,effect of clove extracts on the production of verotoxin by enterohemorrhagic Escherichia coli O157:H7 was investigated by Sakagami et al., (2000) and it was evident from the study that the verotoxin production was inhibited by clove extract.

Antifungal Actions of Essential Oils

Essential oils and their chemical components have been used against fungi especially moulds. The essentials oils extracts from many plants such as basil, citrus, fennel, lemon grass, oregano, rosemary and thyme have shown their considerable antifungal activity against the wide range of fungal pathogens (Kivanc, 1991). Arora and Kaur (1999) observed the sensitivity essential oil of spices against some fungal pathogens and concluded that garlic and clove extracts had the strong ability to inhibit the growth of various candida spp., Rhodotorula rubra, S. cerevisae and Trignopsis variabilis.

Antiviral Actions of Essential Oils

There are many antiviral activities of plant extracted oil has been done so far. The antiviral activity of plant oils were tested against many enveloped DNA as well as RNA viruses, such as herpes simplex virus (DNA viruses), dengue virus (RNA virus), and influenza virus (RNA virus). However, essential oils extracted from oregano and clove were also tested against non-enveloped RNA and DNA viruses, such as adenovirus type 3 (DNA virus), poliovirus (RNA virus), and coxsackievirus B1 (RNA virus) (Wagstaff et al., 1994).

Methods for Extraction Of Essential Oils From Plants

Essential oil is a highly concentrated hydrophobic volatile chemical compounds, generally liquid in form and sourced from different plants. These essential oils have their unique aromatic componential compounds. Distillation is the main method through which these essential oils are generally extracted from plants.

A. Classical (Traditional) and Conventional Methods for Extraction

I. Hydrodistilation
    a. Water distillation
    b. Water and steam distillation
    c. Direct steam distillation
II. Solvent Extraction
III. Soxhlet Extraction
IV. Cold pressing method

B. Modern (Nontraditional) Methods For Extraction

Traditional methods of extraction of essential oils have been discussed and these are the methods most widely used on commercial scale. However, with technological advancement, new techniques have been developed which may not necessarily be widely used for commercial production of essential oils but are considered valuable in certain situations, such as the production of costly essential oils in a natural state without any alteration of their thermosensitive components or the extraction of essential oils for micro-analysis. These techniques are as follows:

I. Headspace trapping techniques
II. Static headspace technique
III. Vacuum headspace technique

IV. Dynamic headspace technique
V. Solid phase micro-extraction (SPME)
VI. Supercritical fluid extraction (SFE)
VII. Phyto sol (phytol) extraction
VIII. Protoplast technique
IX. Simultaneous distillation extraction (SDE)
X. Microwave distillation
XI. Controlled instantaneous decomposition (CID)
XII. Thermomicrodistillation
XIII. Microdistillation
XIV. Molecular spinning band distillation
XV. Membrane extraction

I. Hydro Distillation

First to isolate essential oils by hydro distillation, the aromatic plant material is packed in a still and a sufficient quantity of water is added and brought to a boil; alternatively, live steam is injected into the plant charge. Due to the influence of hot water and steam, the essential oil is feed from the oil glands in the plant tissue. The vapor mixture of water and oil is condensed by indirect cooling with water. From the condenser, distillate flows into a separator, where oil separates automatically from the distillate water.

a. Water Distillation

In this method, the material is completely immersed in water, which is boiled by applying heat by direct fire, steam jacket, closed steam jacket, closed steam coil or open steam coil. The main characteristic of this process is that there is direct contact between boiling water and plant material.

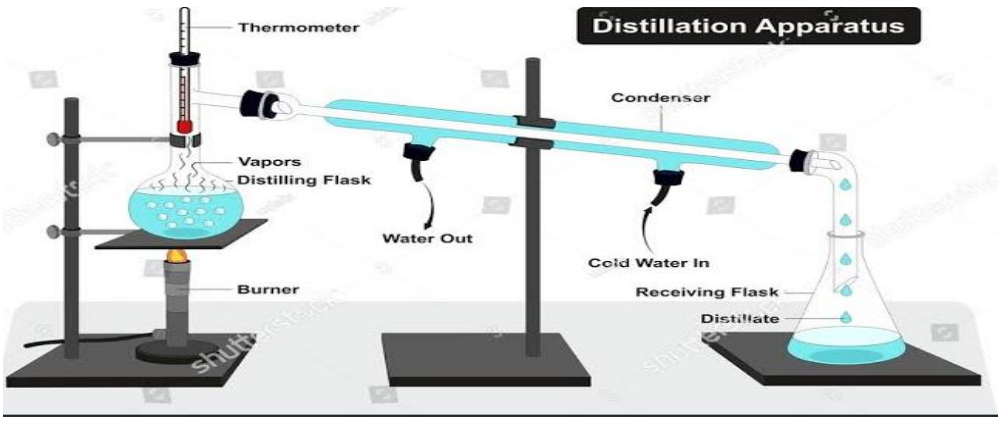

Figure 2: Essential oil recovery by water distillation Method (https://www.shutterstock.com/image-illustration/distillation-apparatus-diagram-full-process-lab-604669949)

The plant material in the still must be agitated as the water boils, otherwise agglomerations of dense material will settle on the bottom and become thermally degraded. water distillation possesses one distinct advantage, i.e. that it permits processing of finely powdered material or plant parts that, by contact with live steam, would otherwise form lumps through which the steam cannot penetrate. The main disadvantage of water distillation is that complete extraction is not possible and is used only in cases in which the plant material by its very nature cannot be processed by water and steam distillation or by direct steam distillation.

b. Water and Steam Distillation

In water and steam distillation, the steam can be generated either in a satellite boiler or within the still, although separated from the plant material. Like water distillation, water and steam distillation is widely used in rural areas. Moreover, it does not require a great deal more capital expenditure than water distillation. Also, the equipment used is generally similar to that used in water distillation, but the plant material is supported above the boiling water on a perforated grid. Steam and water distillation is faster than water distillation, so it is more energy efficient. Many oils are currently produced by steam and water distillation, for example lemongrass is produced in Bhutan with a rural steam and water distillation system.

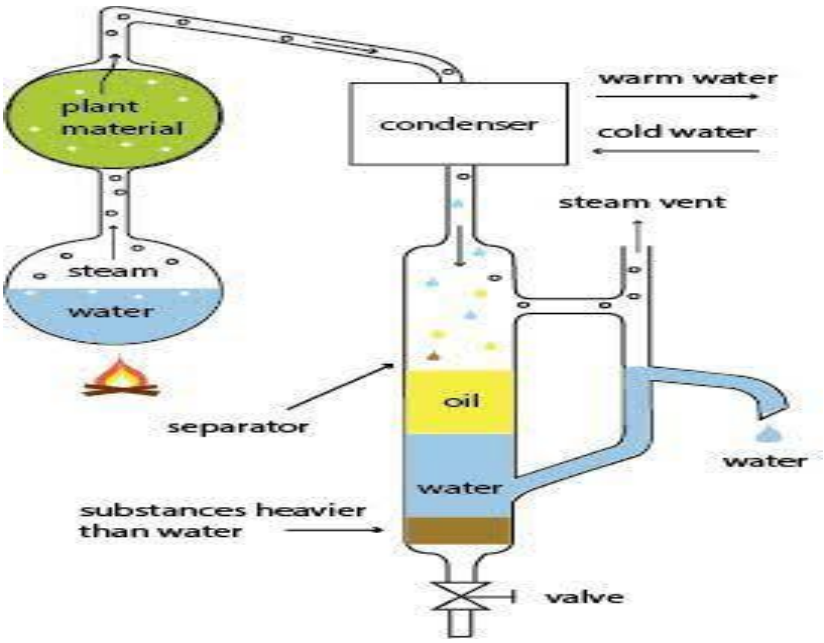

Figure 3: Essential oil recovery by water and steam distillation method (https://www.google.com/search?q=i.pinimg.com/originals/e7/f8/e6/e7f8e65a4f4d0bcaf16318a3d051c82.+jpg&client=ms-android-samsung-garev1&prmd=isnxv&sxsrf=AOaemvKPNT80bOnke04cDR-XPuTheXdhA:1632999449277&source=lnms&tbm=isch&sa=X&ved=2ahUKEwjBkN6AxabzAhU_gtgFHRtJBOIQ_AUoAXoECAIQAQ&biw=412&bih=812&dpr=2.63#imgrc=d2BbrdiJlB9hWM)

c. Direct Steam Distillation

Direct steam distillation is the process of distilling plant material with steam generated outside the still in a satellite steam generator generally referred to as a boiler. As in water and steam distillation, the plant material is supported on a perforated grid above the steam inlet. A real advantage of satellite steam generation is that the amount of steam can be readily controlled. Because steam is generated in a satellite boiler. The plant material is heated no higher than 100° C and, consequently, it should not undergo thermal degradation. Steam distillation is the most widely accepted process for the production of essential oils on large scale. A big sized steel container is taken in which the raw plant material is kept and steam is added to it. By an open inlet, steam is inserted through the same plant material containing the target essential oils, releasing the aromatic bio-molecules and converting them into form of vapor. Then the vaporized different compounds from the plant materials move to the condenser. Here, two individual pipes are used, one to exit the hot water and another to enter cold water across the condenser. This technique cools back the vapor into liquid form. The aromatic by-product liquid drops slowly from the condenser and are collected inside a receiver, known as separator present underneath it, now the essential oil which floats on the top of the water is siphoned off and collected (Kaufmann & Christen, 2002).

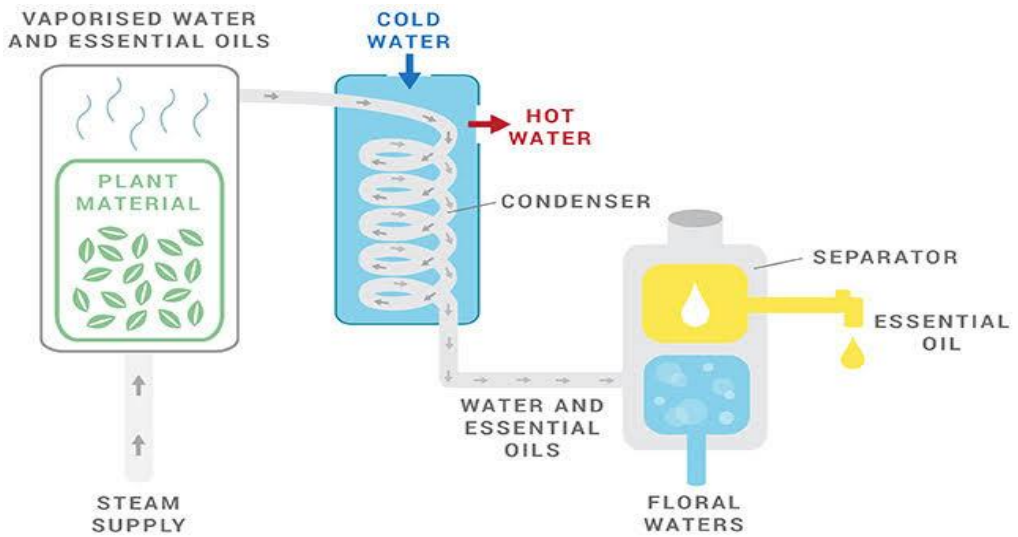

Figure 4: Essential oil recovery by direct steam distillation method (https://www.newdirectionsaromatics.com/blog/articles/how-essential-oils-are-made.html)

II. Solvent Extraction

Solvent extraction, also known as Liquid–liquid extraction or partitioning, is a method to separate a compound based on the solubility of its parts. This is done using two liquids that don't mix, for example, water and an organic solvent. In the Solvent-Extraction method of Essential Oils recovery, an extracting unit is loaded with perforated trays of essential oil plant material and repeatedly washed with the solvent. Solvent extraction is used in the processing of perfumes, vegetable oil, or biodiesel. Solvent extraction is used on delicate plants to produce higher amounts of essential oils at a lower cost (Chrissie et al., 1996). The most frequently applied sample preparation procedure in plant material analysis. The quality and quantity of extracted mixture are determined by the type of extra heat applied because of the method is limited by the compound solubility in the specific solvent used. Although the method is relatively simple and quite efficient, it suffers from such disadvantages as long extraction time, relatively high solvent consumption and often unsatisfactory reproducibility (Dawidowicz et al., 2008).

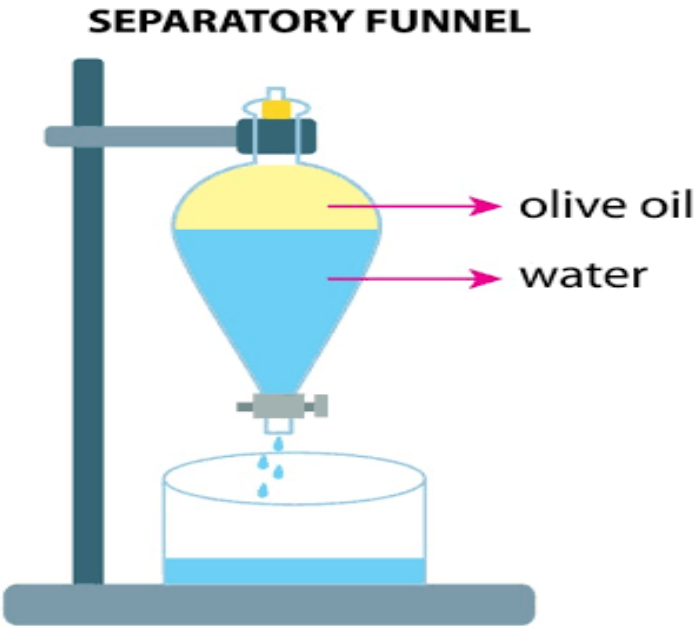

Figure 5: Essential oil recovery by solvent Extraction method (https://www.embibe.com/exams/solvent-extraction/)

III. Soxhlet Extraction

Soxhlet extractor was first designed by Ritter Von Soxhlet in 1879 (Soxhlet 1879) mainly for the extraction of lipid. But now it is widely used for extracting the bioactive constituents from various herbal materials. Soxhlet extractor consists of three parts:1.Flask containing boiling solvent. 2. Soxhlet extractor in which the oil to be extracted is packed. It has a side tube which carries the vapors of the solvent from the flask to the condenser and a siphon tube which siphons off the extract from Soxhlet extractor to the flask..3. A condenser in which the vapors of the solvent condense back into the solvent .

In this method, a finely divided herbal sample is placed in a porous bag or "thimble" made of strong filter paper in an extraction chamber, which is placed on top of a collecting flask, beneath a reflux condenser. A suitable solvent is added to the flask, and the setup is heated under reflux. When a certain level of condensed solvent has accumulated in the thimble, it is siphoned off into the flask beneath. The main advantage of this method is that it is a continuous process and is carried out until the last drop of solvent from the siphon tube leaves the residue. In addition, a large amount of crude oil is also extracted with a much smaller amount of solvent. In terms of time, economy, energy, and financial inputs, it becomes much more viable when converted into a continuous extraction procedure in small to medium batches or on a larger scale. This method cannot be used for thermolabile compounds as prolonged heating may lead to degradation of the compounds.

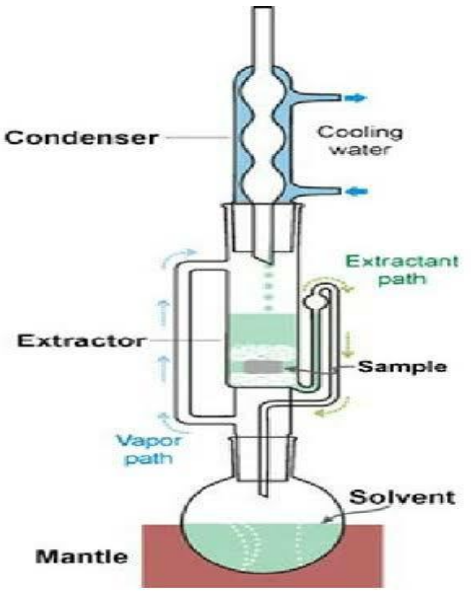

Figure 6: Essential oil recovery by soxhlent method (https://www.researchgate.net/publication/251753895)

IV. Cold Pressing Method

Cold pressed method or expression method is only used in the production of citrus oil. Expression refers to the physical process, in which the essential oil glands in the peel are crushed against a hard object which was placed under a large natural sponge or by bending the peel into the sponge to release the oil. The oil emulsion was removed from the sponge by squeezing in to another container. This oil retains the characteristics fruit odour than the oil produced by other methods. The term cold pressed the erotically means that the oil is expeller-pressed at low temperatures and pressure. Cold pressed method is one of the best methods to extract essential oils. This process is used for most carrier oils and many essential oils. This process ensures that the resulting oil is 100% pure and retains all the properties of the plant. It is a method of mechanical extraction where heat is reduced and minimized throughout the batching of the raw material. The cold pressed method is also known as scarification method. Cold pressed method is mainly used for extracting essential oils from plants, flower, seeds, lemon, tangerine oils (Arnould et al., 1981). In this process, the outer layer of the plants contains the oil are removed by scrubbing. Then the whole plant is pressed to squeeze the material from the pulp and to release the essential oil from the pouches. The essential oil rises to the surface of the material and is separated from the material by centrifugation.

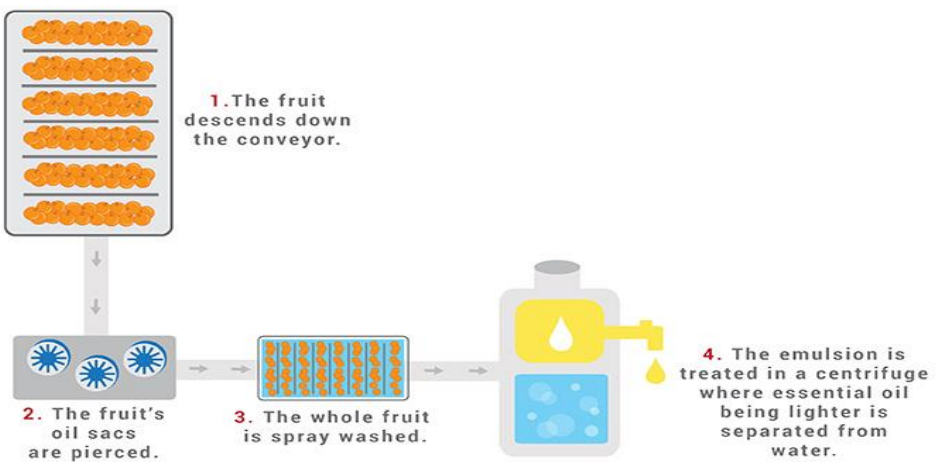

Figure 7: Essential oil recovery by cold pressing method (https://www.newdirectionsaromatics.com/blog/articles/how-essential-oils-are-made.html)

Mechanism of Action of Essential Oils against Pathogenic Microorganisms

The antimicrobial properties of essential oils depend on their chemical constituents and compounds (F. Nazzaro et al.,2013). Through a series of molecular interactions chemical compounds are secreted under specific biotic/abiotic stress conditions (F. Nazzaro et al.,2013),(R. A. Holley et al., 2006).In the bacterial cell the mechanism of antibacterial action is mediated by a series of biochemical reactions, which are dependent on the type

of chemical constituents present in the essential oil (F. Nazzaro et al.,2013).The antibacterial activity of essential oils also differs because of different bacterial architecture, such as Gram-positive and Gram-negative bacteria, which differ in their cell membrane compositions (K. A. Hammer et al.,2011;J. S. Raut et al., 2014).

Effects on Bacterial Cell Wall

Antimicrobial actions of essential oils lead to the leaking of cell membrane and increased the membrane permeability (Lambert et al., 2001; Oussalah et al., 2006).The loss of ions and reduction in membrane potential, collapse of the proton pump and depletion of the ATP pool are directly associated with permeabilization of the cell membranes (Di Pasqua et al., 2006; Turina et al., 2006).The disruption of the cell membrane may assist various vital processes such as energy conversion processes, nutrient processing, the synthesis of structural macromolecules, and the secretion of growth regulators (M. Oussalah et al., 2006).The essential oils affect both the external envelope of the cell and cytoplasm (F. Nazzaro et al.,2013 ; J. S. Raut et al., 2014). Essential oils pass through the cell wall and cytoplasmic membrane may disrupt the structural arrangement of different polysaccharides, fatty acids and phospholipids layers (Burt, 2004; Long bottom et al., 2004).It also coagulate in the cytoplasm and damage lipids and proteins layers (Burt, 2004).The antimicrobial effect of essential oil components such as thymol, menthol and linalyl acetate might be due to bacterial plasma-membranes perturbation of the lipid fractions, which might be affected the membrane permeability and leakage of intracellular materials (Trombetta et al., 2005). The disruption of the cell membrane by essential oils help in various processes such as energy conversion processes, nutrient processing, synthesis of structural macromolecules, and secretion of growth regulators(Oussalah et al., 2006).

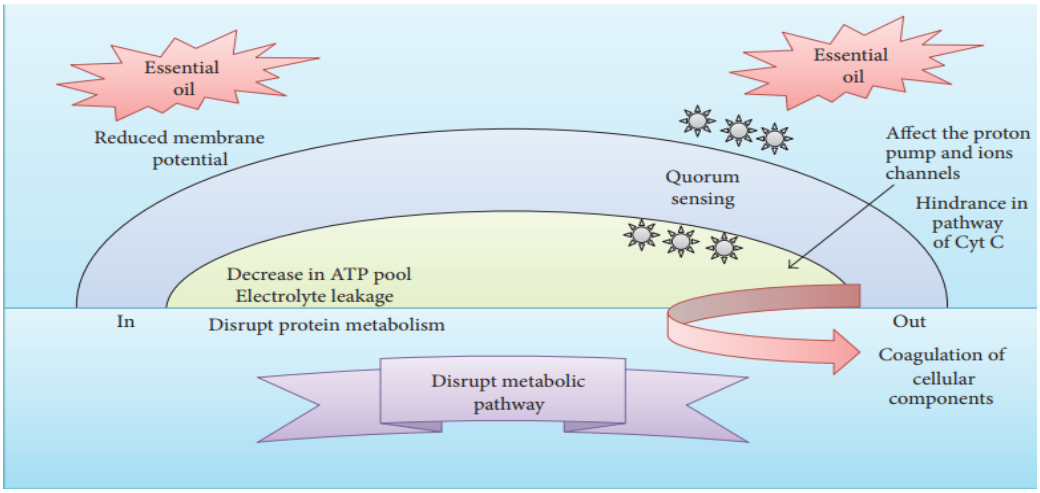

Figure 8: Antimicrobial mechanisms of essential oils on microbes.

Effects On Fungal Cell Wall

The essential oils have the ability to penetrate and disrupt the fungal cell wall and cytoplasmic membranes, permeabilize them and damage mitochondrial membranes (Akthar et al., 2014). The changes in electron flow through the electron transport system inside the mitochondria damage the lipids, proteins and nucleic acid contents (Arnal Schnebelen et al., 2004) of the fungal cells.In yeast cells, essential oils establish a membrane potential across the cell membrane and disrupt the production of ATP, which leads to cell membrane damage (V. Aleksic et al., 2014).The essential oils could also disrupt the depolarization of the mitochondrial membranes by affecting ions channels, especially Ca2+ions, proton pumps, reduce pH and ATP pools, and therefore decrease the membrane potential (Swamy et al., 2016). This change in the fluidity of membranes may cause electrolyte leakage and hinder cytochrome C pathways, proteins metabolism, and calcium ion concentrations. Therefore, the permeabilization of inner and outer mitochondrial membranes may result in the cell apoptosis or necrosis leading to cell death(H. S. Yoon et al., 2000).

Effects on Virus Cell Wall

At present, various essential oils may be a promising alternative against viral infections (K. Bohme et al., 2014). Essential oils might interfere with virion envelopment, designed for entry into host cells (Swamy et al., 2016).For instance, the sesquiterpene triptofordin C-2 was reported to suppress the synthesis of viral proteins and inhibit the early gene expression process of the HSV-1 virus (K. Hayashi et al., 1996).Schnitzler et al.,2011 investigated the antiviral activity of star anise essential oil as well as compounds such as eugenol, *trans*-anethole, farnesol, β-eudesmol, β-caryophyllene, and β-caryophyllene oxide against HSV-1. They found the direct inactivation of HSV-1 particles, which is also reported in another study where eugenol was used (K. Hayashi et al., 1996).Isoborneol (monoterpene) affected the glycosylation process of viral proteins, which inhibited the growth of HSV-1 [M. Armaka et al., 1999).Similarly, essential oils of ginger, thyme, hyssop, and sandalwood were able to inhibit acyclovir-resistant HSV-1 (P. Schnitzler et al., 2001).

Applications of Essential Oils Extracted from Medicinal Plants

Nowadays, essential oils are most widely used as an alternative medicine in different industries like pharmaceutical, agricultural, sanitary and food industries due to their antibacterial, antifungal, antiviral, anticancer, antioxidant activity. Cown (1999) reported that approximately 3,000 EOs are currently available so far,out of which only 300 are of commercially Importance (Hajhashemi et al.,2003; Perry et al.,2003).

Essential Oils as Antibacterial Agents

Nowadays, many EOs are investigated for their antibacterial activities, as well as their inhibitory effects against several Gram-positive and Gram- negative bacteria (Swamy et al.,2016).For examples,(1) Tea tree essential oil having capacity to inhibit respiration in *Escherichia coli.*(2) Lemon essential oil having capacity to inhibit both Gram-positive and Gram-negative bacteria like *Escherichia coli* and *Staphylococcus aureus.(*3) peppermint essential oil having capacity to inhibit the growth of *listeria spp., Salmonella spp.* and

Staphylococcus aureus ,a bacteria that causes skin infections, pneumonia, meningitis and more.(4) cedarwood essential oil having capacity to inhibit the growth of *Bacillus cereus, Bacillus subtilis*and *Escherichia coli.*

Essential Oils as Antifungal Agents

The essential oils which are derived from many medicinal plants such as fennel, lemon grass, citrus, basil, oregano, rosemary and thyme have shown their antifungal activity against broad range of fungal pathogens (Kivanc, 1991).For examples,(1) Arora and Kaur (1999) reported that garlic and clove extract had the strong capacity to inhibit the growth of *Candida albicans, C.apicola, C.catenulata, C.tropicalis, Rhodotorula rubra, saccharomyces cerevisiae.*(2) Oregano essential oil may be a more powerful antifungal than any other commercial medicinal plantproducts that are available and can treat fungal skin infections, including athlete's foot and ring worm.(3) Antifungal activity of EOs has been studied by Juglal et al.,(2002) on viable cell count, mycotoxin production capacity of molds and mycelia growth and concluded that among all the EOs Which are derived from medicinal plants clove, cinnamon and oregano essential oils are most effective against some fungal species like *Aspergillus parasiticus* and *Fusarium moniliforme.*

Essential Oils as Antiviral Agents

The essential oils have been most widely used as antiviral agents for treatment of several viral diseases in human (Koch et al.,2008) and it has also used as alternative to synthetic antiviral drugs (Baqui et al.,2001, Primo et al., 2001)For examples,(1) Oregano oil extracted from *Origanum vulgare* most widely used for inhibit the growth of *Adeno virus*(DNA virus) and (RNA virus).(2) The essential oils extracted from *Artemisa arborescens* most widely used to inhibit the growth of *Herpes simplex virus-1* (HSV-1,DNA virus) which is the cause of most common viral infections in humans like herpetic encephalitis and herpetic keratitis.(3) The essential oils extracted from Zingiber officinale most widely used for inhibit the growth of Adeno virus and Polio virus which are responsible for causation of sever viral infections in humans like polio or poliomyelitis, sore throat, bronchitis, pneumonia, diarrhea, cold like symptoms and fever.

Essential Oils as Antioxidant Agents

Oxidation is one of the major causes of food deterioration and shelf-life reduction in food industry. The oxidation process results in decrease in the nutritional quality, colour, flavor, texture and safety of food. Moreover, oxidation generate some free radicals which contribute to several diseases in humans like cancer, cardiovascular, diabetes, Alzheimer's and heart diseases).One of the best and effective way to reduce oxidation process by generating some EOs from medicinal plants instead of synthetic additives because of serious health issues. For examples,(1) Oregano essential oil having antioxidant activity because it contains thymol and carvacrol, added to several foods like peanut products, dairy beverages, meat and cheese as a food preservative.(2) Clove oil having much strongest antioxidant activity and free radical scavenging activity compared to cinnamon, oregano, thyme, basil EOs (Tomaino et al.,2005).

Essential Oils as Anticancer Agents

Cancer is a generic term for a large group of diseases that can affect any parts of the body. Other terms used are malignant tumors and neoplasms. Cancer is the rapid creation of abnormal cells and which can then invade adjoining parts of the body and spread to other organs; the latter process is referred to as metastatic. metastases are the primary cause of death from cancer.

The malignant cells have the potential to be metastatic, which require urgent treatment like chemotherapy and radiation but this type of treatments are most challenging and cause extreme side effects which can't tolerate by patients who suffering from cancer. So, many alternative ways which are easiest and safe for human health have been developed like production of several EOs from medicinal plants which showing Anticancer activity due to several phytoconstituents like curcumin, thymol, rosmarinic acid, allicin, gingerol perform. Among the alternative traditional approaches in which various medicinal plant products classified as alkaloids, saponins, triterpenes, glycosides and polyphenols shown very promising Anticancer activity both in vitro and in vivo. There are more than one thousand plants which showing significant Anticancer activity. Vineristine, vinblastine, colchicine, ellipticine, taxol, camptothecin, lepachol are classical examples of plant derived compounds which are found to have wide range of applications in cancer therapeutics.

Among the plant derived products EOs from aromatic plants have been reported to consist Anticancer activity. EOs have also been reported to improve the quality of life of the cancer patients by lowering the level of their agony. For examples,(1) Inhibition of primary liver cancer done by curcuma longa (turmeric). (Koo et al., 2004 and Manosroi et al., 2006).(2) Prostate cancer : EOs of Hypericum hircinum having antiproliferative activity on human prostatic adenocarcinoma (PC3).(3) Glioblastoma cancer : EOs of Hypericum hircinum had antiproliferative activity on human glioblastoma tumor cells (T98G).(4) Melanoma cancer : EOs of Afrostyrax lepidophyllus and Scorodophloeus zenkeri exhibited a strong growth inhibitory effect on human malignant melanoma A375 cell line.(5) Breast cancer : EOs of A.lepidophyllus and S.zenkeri also inhibited the growth of human breast adenocarcinoma MDA- MB231 cell line.(6) Colon cancer : A.lepidophyllus and S.zenkeri exhibited a strong growth inhibitory effect on human colon carcinoma HCT116 cell line. Geraniol, a monoterpene found in EOs of various fruits and herbs has been most widely used as agents for chemoprevention, as it has antiproliferative activity on colon cancer cells.(7) Protection against colorectal cancer : Olea europaea (olive oil) (Gill et al.,2005).

Essential Oils as Antidiabetic Agents

Diabetes mellitus (DM) generally known as diabetes is a group of metabolic disorders characterized by high blood sugar (glucose) levels, that results from defects in insulin secretion, or action, or diabetes was first identified as a disease associated with "sweet urine", and excessive muscle loss in ancient world. Blood glucose levels are tightly controlled by insulin, a hormone produced by the pancreas. There are two main types of diabetes shown in humans (1) Type – 1 : insulin dependent diabetes mellitus (IDDM) (2) Type – 2 : non- insulin dependent diabetes mellitus (NIDDM).

Nowadays, several medicinal plants are the potential sources of the drugs to treat diabetes with little side effects , low cost , easy and wide availability and experimentally

evaluated in comparison to any synthetic compounds and therapy. For examples, (1) Fenugreek (Trigonella foenum-graecum) may also increase the number of insulin receptors in red blood cells and having potential antidiabetic effects both on pancreas and other sites.(2) Turmeric (Curcuma longa) increase the regulation of liver function.(3) Karela/ Bitter melon (Momordica chinensis) contain another bioactive compound i.e, lectin that has insulin like activity.(4) Cinnamon (Cinnamomus zeylanicum) exhibit insulin like activity in cells, animals and people with type- 2 diabetes.(5) Amla (Emblica officinale) fruit was evaluated for anti-hyperglycaemic and lipid lowering properties in humans.

Essential Oils as Insect Repellents

Insect repellents are an alternative to the insecticides. Insecticides (used to kill insects like mosquitoes, ticks, cockroaches,etc.). It is commonly known as bugspray. An individual can be protect from insects bites by using this types of insect repellents by applied to the skin surface or clothing. Nowadays , a natural insect repellent isa spray or lotion, applied to the skin for the prevention of insects bites instead of synthetic / chemical insect repellents. Natural insect repellents were preferred over chemical insect repellents because they are causing concerns regarding human health and environmental pollution. Natural insect repellents are most widely derived from several medicinal plants especially essential oils. EOs are volatile and complex mixtures of hydrocarbons (monoterpenes and sesquiterpenes) also contain different functional groups like (alcohols, aldehydes, ketones, ethers, esters, phenols For examples,(1) EOs from *Eucalyptus camaldulensis, Pimpinella anisum* most widely used against Culex pipiens (Edler et al.,2006).(2) EOs from *Mentha piperita* exhibit insecticidal properties against some insects like Anopheles annularis, Anopheles Culicifaciens, C. quinquefasciatus (Ansari et al., 2000 (3) EOs from *Cinnamomus zeylanicum* produce natural insect repellents which actively against Anopheles *stephensi, A. aegypti*and *C. quinquefasciatus* (Prajapati et al., 2005).

Conclusion

Essential oils (EOs) are natural products which contain wide range of volatile molecules such as terpenes and terpenoids , phenol derived aromatic and aliphatic compounds. This component having Antibacterial, Antiviral, Antifungal, Anticancer, Antioxidant activity. They have been used for several applications in cosmetic, pharmaceutical, agricultural,etc. EOs attack directly the cell membrane of the pathogenic microorganisms by causing an increase in permeability and leakage of vital intracellular components and finally disrupt the cell respiration and microbial enzyme system. EOs derived from medicinal plants are used as an alternative for discovery of new and safe drugs.

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