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The Aromatic World of Medicinal Essential Plant Oils: Extraction, Attributes and Utilization

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Abstract
The history of using plants for medicinal purposes dates back to ancient Indian medicine. Natural products, derived from various sources, have played a significant role in treating and preventing diseases worldwide. The World Health Organization recognizes the importance of traditional medicine and has created guidelines and standards for botanical medicines. Aromatic plants in Saudi Arabia are excellent sources for essential oils (EO), which have antimicrobial properties and are used in various industries. EOs, such as seeds, leaves, and stems, are essential components of plants. In this review some applications of Medicinal Essential oils is discussed.

Keywords: Essential oil, Medicine.

1. Introduction

Local people have long history of tradition of using plants for medicinal purposes. Later, ancient doctors (primitive medical system) empirically studied and recorded the properties and therapeutic uses of medicinal plants, which form the basis of ancient Indian medicine [1]. The medicinal plant is an important part of indigenous medical systems around the world. Although modern medicine can coexist with such traditional practices, herbal medicines have often maintained their popularity for historical and cultural reasons [3]. Natural products have played an important role in the treatment and prevention of human diseases around the world. Natural medicines are derived from various starting materials, including terrestrial plants, soil microorganisms, marine organisms, and terrestrial vertebrates and invertebrates [4], and their importance in modern medicine has been discussed in various reviews and reports [5].The value of natural products in this regard can be seen: 1) as a model for the introduction of new, structurally diverse chemical units, including semi-synthetic and full synthetic conversion, 2) by the number of diseases treated or prevented. In recent years, the use of traditional medicine knowledge in plant research has again attracted great interest [6]. Recently, there has been an increased interest in the study of the chemistry of natural products. This interest is due to several factors, including unmet therapeutic needs, the remarkable diversity of chemical structure and biological activity of naturally occurring secondary metabolites, the use of new bioactive natural compounds as biochemical probes, and the development of new and sensitive techniques. The World Health Organization (WHO) also recognized the importance of traditional medicine and created strategies, guidelines, and standards for botanical medicines. Cultivation and processing of medicinal plants and production of herbal medicines must use proven agro-industrial techniques [8].

Medicinal plants are an excellent source of various bioactive secondary metabolites that are used in the development of innovative agents' therapeutic agents with novel health benefits. from Saudi Arabia 'Arabia' is an excellent source of various medicines and aromatic plants. Many Saudi Arabian plants differ from the same plants due to their chemical diversity and medicinal effects grows separately in other regions and climate's geographical location of the country [9]. Various aromatic plants growing in Saudi Arabia have been reported as promising sources for EO production [2]. Aromatic plants thanks to them, substantial amounts of EO can be used as a therapeutic option for the treatment of various diseases. known efficiency. EO is a chemical mixture of aromatic substances ingredients that have a strong smell and are extracted of aromatic plants. EO are complex combinations bioactive ingredients with different structures such as e.g., mono-, sesqui- and diterpenes, phenolic elements, sulphur-containing components and phenylpropanoid components. [10]. The powerful antimicrobial properties of EO can help to overcome the problems of high bacterial resistance due to the excessive costs of current medicines and antibiotics of the last generations [11]. A large selection of bioactive substances Components of resistance mechanisms of EO blocks different bacteria interact with cellular enzymes or cellular structures of invasive microorganisms that increases the rate of microbial cell death [12]. Except them excellent antimicrobial properties, EO and their components are used in perfumes, cosmetics, pharmaceuticals, aromatherapy, hygiene products, dentistry, agriculture, food preservatives and additives and natural improvers [13]..

1.1. ESSENTIAL OILS:

Essential oils are aromatic, fragrant liquids secondary metabolism of plants. They are called "important" because they are the most important parts of the plant. EO exists as a mixture of organic components of various plants from sources, they give the plants a strange smell [14,15]. Different organs of aromatic herbs are used for distillation. EOs, such as seeds (cumin, cumin and coriander), leaves (peppermint, thyme, sage, rosemary, oregano, basil, celery and parsley), fruits (anise, fennel and lemon), stems (rose and rosemary), bark (cinnamon), pods or buds (cloves and garlic) and rhizomes (ginger) [14]. Aromatic plants can synthesize EOs as organic compounds cytoplasmic elements and plastids of plant cells various pathways including mevalonic acid, malonic acid acid and methyl-D-erythrol-4-phosphate (MEP), they store it in epidermal cells, secretes pressure, glandular trichomes, or resin channels [16,17]. Characteristic smell and color EO depend on the origin of plants, species and organs. The general color of EOs is pale yellow or colorless, uniform although some have a deep color such as green valerian and blue chamomile [14]. The compounds found in spores have an important environmental factor work because they can protect plants from invasive bacteria, fungi, insects and viruses and are also able to attract certain insects to pollinate plants [13]. Plant essential oils have a different chemical composition depending on the geographical location, environment and maturity are all factors which can affect the plants and the percentage of essential oils in them [17,18].

1.2. NATURE OF ESSENTIAL MEDICINAL OILS:

Terpenes and phenylpropanoids are two properties chemical groups that make up most plant EOs. terpenes and terpenoids are the main components of various EOs, in some species, however, they are represented by phenylpropanoids the main components of these EOs, which give such oils their specific aroma and taste [6,19,20]. The main elements of EO are obtained by three chemicals pathways: mono- and diterpenes are synthesized by by the methylerythritol pathway, sesquiterpenes are synthesized by the mevalonate pathway and phenylpropenes by the shikimic acid pathway [18]. Separate secondary metabolites

(terpenes, aldehydes, ketone alcohols, esters and phenylpropanoids) plants are the main key factors affecting the chemical properties of the EO of each plant [21]. Condensation of several isoprene units form various terpenes such as mono-, di-, sesqui-, tri-, tetra- and polyterpenes. Figure 1 shows β-cymene, limonene, Sabine, β-myrcene and γ-terpene as examples of monoterpenes [22]. Certain enzymes change the chemical structure of terpenes forming various terpenoids with different chemical structures and different positions of the hydroxyl groups (Figure 1), i.e such as menthol, carvacrol, α-terpineol, geraniol and thymol [23]. Phenylpropanoids such as cinnamaldehyde, safrole, eugenol and isoeugenol are few. in most EOs (Figure 1) [5, 17]. EO chemical components and concentrations vary between different plant species and due to differences in plants within similar species part, harvest time, drying, storage, distillation process, and climate issues [24]. The chemical properties of EO are different ingredients in concentration and type and their stereochemical structures that can be affected with the extraction method used. Essential oils are natural mixtures of organic compounds containing 20 to 100 different volatile compounds of different chemical classes, only two or three molecules whose percentages (20-70%) responsible for various properties of EOs [23]. In this agreement, Bakkali et al. [5] showed that the main components of Origanum EO were carvacrol and thymol with a high percentage of 30% and 27% and the highest percentage (68%) was linalool observed in Coriandrum EO. a large percentage (50%) 1,8-cineole was characteristic of Cinnamomum EO and high in Artemisia EO α- and β-thudone concentrations (57%) except 24% camphor Mentha EO also stood out high contains 59% menthol and 19% menthol, while 36% of α-phellandrene and 31% of limonene were discovered in Anethum leaf EO and 58% of hair and 37% limonene was found in the EO of Anethum seeds [15]. In addition, methylcarvacrol (13.4%), carvacrol (55.7%), δ-3-carene and β-bisabolene (9.1%) are the main components. The most important of **Lavandula pubescens** oil is linalool (33.0%) Pulicaria incisa component and δ-3-carene (7.3-30.3%) and α-pinene (31.3-62.5%) is the main component **Juniperus procera** [26].

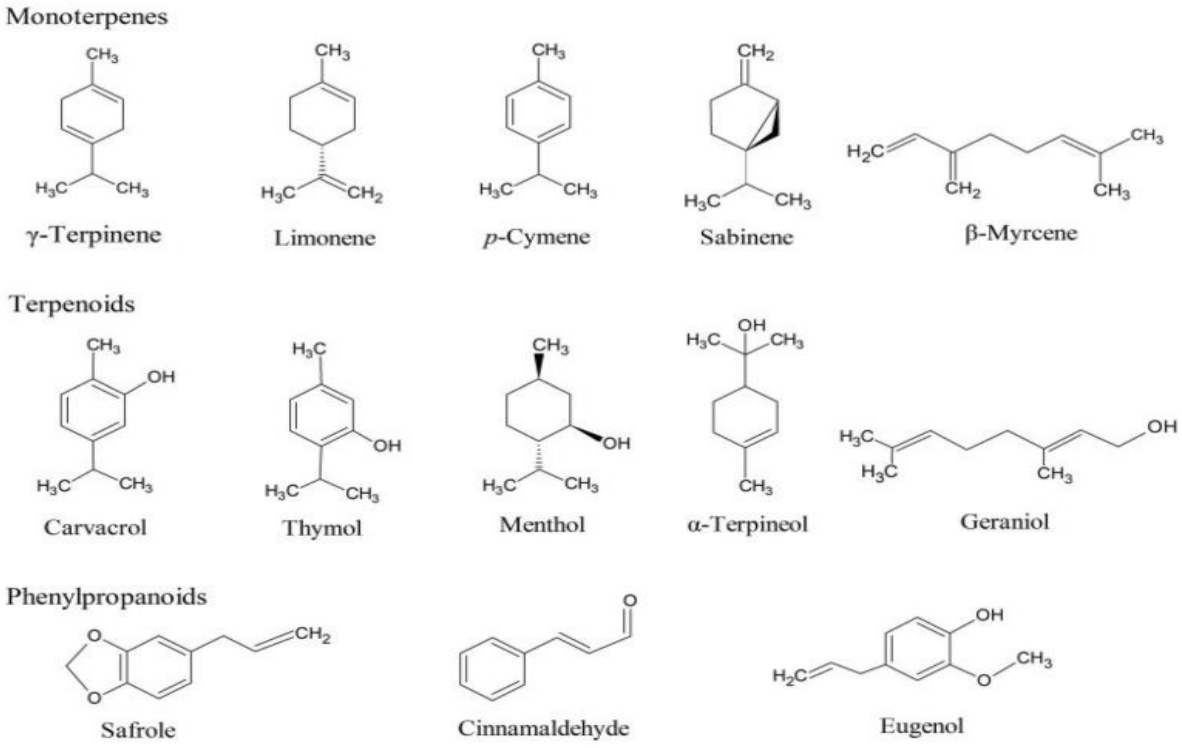

Fig.1 Different Essential Oils

2. EXTRACTION OF ESSENTIAL OILS:

Two main steps are used to analyse plants EN: Extraction/distillation of oil, which takes several hours and a chemical analysis that takes several minutes. Various extraction/distillation methods are used refine plant EOs, Figure 2 explains this after the previous one Farhat et al. [20]. Thanks to fickle nature.

EOs, hydro distillation using the Clevenger system is available conventional system applied to the processing of EO on a laboratory scale. Although steam distillation is common system applied to EO processing in industrial production [21]. Solution extraction of EO is mainly used however, it is limited in industrial practice due to its significant toxicity in the food industry organic solvents [22]. There are other different techniques were reviewed to improve EO extraction in industry application efficiency, sustainability and economy. The system includes microwave and ultrasound assisted extraction and ohmic water distillation system [18, 23]. The extraction method is the most used an important factor in ensuring the quality of essential oils, because wrong extraction methods can change the chemical composition of aromatic oils and change their quality and function [18]. Also, when the steam distillation process is available. Chemicals used for EO extraction are always used be volatile, while solvents are used for Eos extraction, the while solvents position differs from that of a similar essential oil obtained by distillation. Because the chemical composition of any oil is affected used the extraction method choosing the correct extraction method based on the properties of each plant material is a critical point. Annual recovery of EOs should be produced under the same conditions to maintain consistency in chemical composition, quality and quantity, e.g using similar plant parts, similar extraction process, and a similar harvest time. The plant parts collected for extraction can be collected fresh, partially dried or dried, but the seeds must be picked fresh [24] Essential oils can be extracted from several plants using different extraction methods. The preparation of essential oils and the method of essential oil extraction usually depends on the botanical material used [22]. The space and shape of the material is another factor to consider. The extraction method is one of the most important factors that determine the quality of an essential oil [23]. Improper extraction methods can damage or change the chemical character of an essential oil. This leads to the loss of biological activity and natural properties. In severe cases, discoloration, unpleasant odor/taste, and physical changes such as increased viscosity may occur [25]. These changes in the extracted essential oil should be avoided. Essential oils can be extracted in different ways [24].

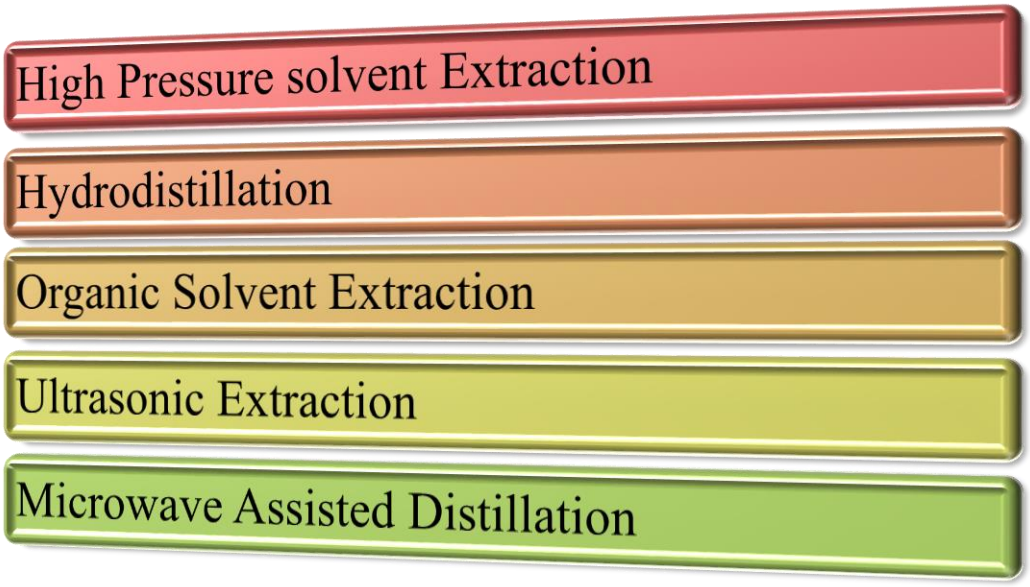

Fig. 2. Methods of Extraction of Essential Oils

3. Applications:

Medicinal Essential oils Have Diverse Applications But some of them are discussed below.

3.1. Biological activities of essential oils:

Various aromatic herbs have existed since early times used as preservatives and medicines. The main source of aroma and popularity is in the food industry. EOs is the main reason for the therapeutic effect in various aromatic herbs. The different biological effects of EO are not only those key compounds (two or three compounds that are present in high percentages) but can also be strong effect of synergy of other active ingredients [25]. Essential oils are mainly used in the pharmaceutical industry for aromatherapy and sensory enhancement pharmacological drugs. Various traditional systems around the world use EO to treat a wide range of health problems. For example, eucalyptus EO to treat bronchitis and cough, sage and clove to prevent growth of various bacteria, Peppermint EO treats any respiratory congestion and anise and peppermint EOs are known as carminatives [26, 27]. Different experimental studies show different therapeutic properties EO and their main components.

3.2. Essential oils as antibacterial agents:

An increase in antibiotic resistance, which leads to due to the inadequacy of antimicrobial therapy, antimicrobial chemotherapy is a major challenge. The main factor promoting the development of different types of the cause of resistant bacteria is considered to be the excessive use of antibiotics and the resulting pressure of antibiotic selection. Factory bioactive substances including EO had strong antibacterial activity ability against various Gram-negative compounds with gram-positive bacteria [31, 39]. Because of their strong antibacterial effect, different EOs and their key molecules have reached a high consciousness that can be used various useful add-ons to increase storage period of food ingredients to ensure microbiological safety for consumers [40]. Effective antimicrobial properties as EO are created, these properties are usually affected by presence and concentration of some EO components, including phenylpropanoids, terpenoids, alcohols, terpenes, aldehydes, ketones and esters [14, 25,26]. The EOs showed different biochemistry mechanisms against various microorganisms, including the ability of hydrophobic elements of EO to interact with the lipids of cell membranes of microorganisms, which caused damage to membrane permeability and force that cause great differences in the circuit of electron transport, nutrient consumption methods and in synthesis of nucleic acids and proteins, therefore induces coagulation of cell contents and inhibits various metabolic enzymes, causing cell death [22]. after bacterial membranes, EO bioactive substances, e.g. may well inactivate bacterial cells by entering the cell and inhibit protein, RNA, DNA or polysaccharides [27]. Various EOs including thyme, cinnamon, oregano, clove, Lemongrass and rosewood have shown strong antibacterial properties [27]. Antibacterial efficacy of different EOs the activity against E. coli is highly concentration dependent. Bay EO activity was highest at 0.02%, clove at 0.04%, oregano 0.05%, lemongrass 0.06% and thyme by 0.05%. Peppermint, rosemary, cloves, by, Lemongrass and thyme have shown significant antibacterial properties ability against S. aureus at <0.05% concentration. Also 1% eucalyptus and basil EO concentration showed mild antibacterial activity [23]. In addition, tea tree, the powerful antibacterial effect of lemon myrtle, and garlic EOs compared to methicillin-resistant S . aureus (MRSA) was established [24]. Antibacterial effect of helmets, cinnamon, tamarind, black cumin, nutmeg, garlic, onion, and pomegranate seeds EO against Salmonella enteritidis and Listeria monocytogenes were found [23]. Various natural EOS fennel fruits, collected in Portugal, showed little or mild antibacterial activity compared to S. enteritidis, E. coli, P. aeruginosa and P. mirabilis [26]. The main

components of the EO had antimicrobial activity more than their crude oils, key molecules such as eugenol and carvacrol in clove oil and terpin-4-olin tea tree oil, showed excellent antimicrobial ability compared to their raw EO [17]. Excellent antimicrobial properties of various phenylpropanoids such as eugenol, cinnamaldehyde, isoeugenol and safrole have been demonstrated [17]. Various studies different operating modes of different EOs were discussed different bacteria, such as Behbahani et al. [48] noted that cumin EO application Listeria innocuous and E. coli negatively affected bacterial cell permeability membranes that led to the disassembly of cellular components and cell death. Similarly, copticum EO showed effective antimicrobial activity against E. coli by damaging cell membrane integrity, forming. Many pores and then cell lysis [29]. As well as treatment S. aureus and Artemisia Argy EO induced growth on the permeability of the bacterial cytoplasmic membrane, which caused leakage of proteins and K ions and cell death [50]. Alternative treatment of L. monocytogenes with citrus fruits Chagshan-Huyou EOs and carvacrol showed different morphological modifications in bacterial cells including split, wrinkled and shriveled leaves and fragmented cells [27,28]

3.3 Essential oils as Antifungal agents:

Various aromatic plants and essential oils were introduced strong antifungal activity against various pathogens, fungi, including yeasts. Antifungal activity of EOs depends on the target pathogen and the oil used. The fennel, coriander, and anise volatile oils good antifungal activity against Candida albicans at different concentrations of 1%, 0.5% and 0.25%.[43]. Volatile oils of geranium, Japanese mint, cinnamon, clove, ginger and lemongrass in different concentrations (0.01-0.15%) showed strong antifungal activity against C. albicans [43]. The volatile oil of Lavandula multifda also had strong antifungal activity against C. albicans [43]. Cymbopogon sp. EO showed great antifungal activity compared to pathogenic yeasts [54]. eugenol, phenylpropanoid molecule and β-bisabolol, a monocyclic sesquiterpene alcohol, showed excellent antifungal activity. The abilities against various dermatophytes and their spores [15]. Lemongrass volatile oil showed the highest antifungal activity against Aspergillus favus at the concentrations. (0.006-0.03%), inhibiting fungal growth and aflatoxin production [39]. Antifungal properties of lemon in the concentration of tangerine, grapefruit and orange oils 1% occurred against various species of Aspergillus and Penicillium molds [43].

Different EOs and their items had the highest antifungal activity against drug-resistant C. albicans biofilms due to film suppression. Ergosterol and variable signaling pathways that inhibit hyphal morphogenesis from yeast [43]. In addition, citral (key eucalyptus oil molecule), citronellol (key molecule of tea). wood oil) and geraniol and geranyl acetate (main molecules geranium oil) significantly inhibit the cell C cycle. albicans in S phase [42]. Similarly, a curl of hair, eugenol and thymol inhibit the growth of S. cerevisiae by disrupting the homeostasis of Ca^{+2} and H^{+} ions [43].

3.4 Essential oils As an Antioxidant:

Different EOs have a strong antioxidant effect have been reported in many studies because they have non-toxic impact on health. New different reports recommend the use of natural antioxidants, including EO, because of the toxic effects of using unnatural antioxidants to human health, including butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT) [28]. An excellent antioxidant compound can transfer an electron to the active free radical to deactivate the one that makes it more stable and less dangerous. Antioxidants protect organelles of oxidative degradation by scavenging free radicals [29]. Various studies have been used several in vitro chemical assays for antioxidant evaluation. The power of EOs. Diphenyl-

1-picrylhydrazyl (DPPH) and 2,2'-Azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) are commonly used assays that used stable radicals (DPPH and ABTS) as probes.

To measure the ability to scavenge free radicals. In the year DPPH assay (Figure 4), electron/hydrogen donating antioxidant compounds in EO donate electron DPPH radical, it changes the color of DPPH from purple colorless, depending on the strength of the antioxidant composition The degree of color change is calculated using UV radiation as absorbance values at 519 nm spectra, these absorbance values represent antioxidant activity, and a high absorbance value means high antioxidant effect [30]. Excess reactive oxygen species and excess free radicals cause an event of oxidative stress in which various macromolecules in the cell are damaged, causing many health problems such as aging, cancer, diabetes, arteriosclerosis, and Alzheimer's disease [31]. Also, many free radicals in the body cause cellular damage that has been linked to chronic diseases such as heart disease and cancer. Various natural antioxidants including EO bioactive agents can control the production of excess free radicals in the body by effectively scavenging free radicals. Antioxidant potential of volatile oils of various aromatic plants against DPPH and ABTS was investigated. Like Eos of Oregano, Tagetes, and Bacopa had significant antioxidant activity [33]. Thyme and savory EOs presented excellent DPPH and free radical scavenging ability ABTS, ABTS The scavenging activity of EOs was significantly higher than DPPH [34]. Various species of mentha, sage, turmeric, yarrow, melaleuca and ocimum EOs showed strong free radical scavenging/antioxidant activity properties [35, 36]. In another study, Romeilah et al. [37] demonstrated the effective free radical scavenging ability of Petroselinum, Coriandrum, Cuminum and various Allium species. In addition, Tomaino et al. [38] evaluated the radical scavenging and antioxidant efficacy of several EOs and found that fiery EOs was the highest, followed by cinnamon, nutmeg, basil, oregano, then thyme. So are many studies evaluated the antioxidant properties of the main constituents of different EOs such as Miguel [32] that thymol, the main component of Thymus EO, and carvacrol, the main component of Origanum EO, were present with excellent antioxidant properties.

4. Conclusion:

Essential oils among natural plant products require special attention because they are used in many traditional healing systems around the world. This review seeks to highlight the nature, benefits, ingredients, and various aromas of essential oils herbs that produce volatile oils. Findings to be discussed in

This review is expected to be of interest to researchers looking for new natural and effective agents that act as antimicrobial agents against emerging resistant microorganisms, in addition to those interested in therapeutics. various volatile oils, especially for oxidative processing stress-related illnesses. Current information updates information on the different modes of action of volatile oils as antimicrobial agents, helping new applications in essential oil processing. Essential oils and their bioactive ingredients more clinical trials should be done to help develop new therapeutic products from it.

REFERENCES

1. Prakash, P. and Gupta, N. (2005) Therapeutic Uses of Ocimum sanctum Linn (Tulsi) with a Note on Eugenol and Its Pharmacological Actions: Review. Indian Journal of Physiology and Pharmacology, 49, 125-131.
2. Farnsworth, N.R. (1990) The Role of Ethno Pharmacology in Drug Development. Ciba Foundation Symposium 154. Bioactive Compounds from Plants. John Wiley & Sons, Baffins Lane, Chichester (England), 2-21.

3. Vishwakarma, A.P., Vishwe, A., Sahu, P. and Chaurasiya, A. (2013) Magical Remedies of Terminalia arjuna (ROXB.). International Journal of Pharmaceutical Archive, 2, 189-201.
4. Newman, D.J., Crag, G.M. and Snader, K.M. (2000) The Influence of Natural Products upon Drug Discovery. Natural Product Reports, 17, 215-234. http://dx.doi.org/10.1039/a902202c
5. Jones, W.P., Chin, Y.-W. and Kinghorn, A.D. (2006) The Role of Pharmachology in Modern Medicine and Pharmacy. Current Drug Targets, 7, 247-264. http://dx.doi.org/10.2174/138945006776054915 [Citation Time(s):2]
6. Newman, D.J. and Crag, G.M. (2007) Natural Products as Sources of New Drugs over the Last 25 Years. Journal of Natural Products, 70, 461-477. http://dx.doi.org/10.1021/np068054v[Citation Time(s):1]
7. Clark, A.M. (1996) Natural Products as a Source for New Drugs. Pharmaceutical Research, 13, 1133-1141. http://dx.doi.org/10.1023/A:1016091631721 [Citation Time(s):1]
8. WHO (1993) Research Guidelines for Evaluating the Safety and Efficacy of Herbal Medicines. Manila. [Citation Time(s):1]
9. El-Said H, Ashgar SS, Bader A et al (2021) Essential oil analysis and antimicrobial evaluation of three aromatic plant species growing in Saudi Arabia. Molecules 26:959
10. Soliman SS, Alsaadi AI, Youssef EG et al (2017) Calli essential oils synergize with lawsone against multidrug resistant pathogens. Molecules 22:2223
11. Oliva A, Costantini S, De Angelis M et al (2018) High potency of melaleuca alternifolia essential oil against multi-drug resistant gram-negative bacteria and methicillin-resistant Staphylococcus aureus. Molecules 23:2584
12. Tisserand R, Young R (2013). Essential oil safety: a guide for health care professionals. Elsevier Health Sciences, Amsterdam
13. Sirousmehr A, Arbabi J, Asgharipour MR (2014) Efect of drought stress levels and organic manures on yield, essential oil content and some morphological characteristics of sweet basil (Ocimum basilicum). Adv Environ Biol 8:880–885
14. Prakash B, Kedia A, Mishra PK, Dubey NK (2015) Plant essential oils as food preservatives to control moulds, mycotoxin contamination and oxidative deterioration of agri-food commodities–Potentials and challenges. Food Control 47:381–391
15. Sharif-Rad J, Sureda A, Tenore GC et al (2017) Biological activities of essential oils: From plant chemoecology to traditional healing systems. Molecules 22:70
16. Swamy MK, Sinniah UR, Akhtar M (2015) In vitro pharmacological activities and GC-MS analysis of diferent solvent extracts of Lantana camara leaves collected from tropical region of Malaysia. Evid Based Comple Alternat Med. https://doi.org/10.1155/ 2015/506413
17. Arumugam G, Swamy MK, Sinniah UR (2016) Plectranthus amboinicus (Lour.) Spreng: botanical, phytochemical, pharmacological and nutritional signifcance. Molecules 21:369. https:// doi.org/10.3390/molecules21040369
18. Baser KHC, Buchbauer G (2009) Handbook of essential oils: science, technology, and applications. CRC Press
19. Zuzarte M, Salgueiro L (2015) Essential oils chemistry. In Bioactive essential oils and cancer. Springer, Cham, p 19–61. https:// doi.org/10.1007/978-3-319-19144-7_2

20. Tohidi B, Rahimmalek M, Trindade H (2019) Review on essential oil, extracts composition, molecular and phytochemical properties of Thymus species in Iran. Ind Crops Prod 134:89–99
21. Sharma SH, Thulasingam S, Nagarajan S (2017) Terpenoids as anti-colon cancer agents–A comprehensive review on its mechanistic perspectives. Eur J Pharmacol 795:169–178
22. Gyawali R, Ibrahim SA (2014) Natural products as antimicrobial agents. Food Control 46:412–429 17. Hyldgaard M, Mygind T, Meyer RL (2012) Essential oils in food preservation: mode of action, synergies, and interactions with food matrix components. Front Microbiol 3:12
23. Megawati FD, Sediawan WB, Hisyam A (2019) Kinetics of mace (Myristicae arillus) essential oil extraction using microwave assisted hydrodistillation: efect of microwave power. Ind Crops Prod 131:315–3
24. Chouhan S, Sharma K, Guleria S (2017) Antimicrobial activity of some essential oils—present status and future perspectives. Medicines 4:58
25. El-Said H, Ashgar SS, Bader A et al (2021) Essential oil analysis and antimicrobial evaluation of three aromatic plant species growing in Saudi Arabia. Molecules 26:959.
26. J. Umm Al-Qura Univ. Appll. Sci. (2023) 9:40–49 | https://doi.org/10.1007/s43994-022-00018-1
27. Guo J, Gao Z, Li G et al (2019) Antimicrobial and antibioflm efcacy and mechanism of essential oil from Citrus Changshanhuyou YB chang against Listeria monocytogenes. Food Control 105:256–264
28. Churklam W, Chaturongakul S, Ngamwongsatit B, Aunpad R (2020) The mechanisms of action of carvacrol and its synergism with nisin against Listeria monocytogenes on sliced bologna sausage. Food Control 108:106864
29. Firuzi O, Miri R, Tavakkoli M, Saso L (2011) Antioxidant therapy: current status and future prospects. Curr Med Chem 18:3871–3888
30. Liang N, Kitts DD (2014) Antioxidant property of cofee components: assessment of methods that defne mechanisms of action. Molecules 19:19180–19208
31. Edris AE (2007) Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents: a review. Phytotherapy Res 21:308–323
32. Miguel MG (2010) Antioxidant and anti-inflammatory activities of essential oils: a short review. Molecules 15:9252–9287
33. Tripathi R, Mohan H, Kamat JP (2007) Modulation of oxidative damage by natural products. Food Chem 100:81–90
34. Aebisher D, Cichonski J, Szpyrka E et al (2021) Essential oils of seven lamiaceae plants and their antioxidant capacity. Molecules 26:3793
35. Gulluce M, Sahin F, Sokmen M et al (2007) Antimicrobial and antioxidant properties of the essential oils and methanol extract from Mentha longifolia L. ssp. longifolia. Food Chem 103:1449–1456
36. Hussain AI, Anwar F, Sherazi STH, Przybylski R (2008) Chemical composition, antioxidant, and antimicrobial activities of basil (Osmium Basilica) essential oils depends on seasonal variations. Food Chem 108:986–995
37. Romelia RM, Fayed SA, Mahmoud GI (2010) Chemical compositions, antiviral and antioxidant activities of seven essential oils. J Appl Sci Res 6:50–62
38. Hammer KA, Carson CF, Riley TV (1999) Antimicrobial activity of essential oils and other plant extracts. J Appl Microbial 86:985–990
39. Hammer KA, Carson CF (2011) Antibacterial and antifungal activities of essential oils. Lipids Essent Oils Antimicrobial Agents 77:256–293

40. Irkin R, Kouilou M (2009) Effectiveness of Cymbopogon citratus L. essential oil to inhibit the growth of some filamentous fungi and yeasts. J Med Food 12:193–197
41. Viuda-Martos M, Ruiz-Navajas Y, Fernández-López J, PérezÁlvarez J (2008) Antifungal activity of lemon (Citrus lemon L.), mandarin (Citrus reticulata L.), grapefruit (Citrus paradisi L.) and orange (Citrus sinensis L.) essential oils. Food Control 19:1130–1138
42. Essential oils of some medicinal plants and their biological activities: a mini review Amal A. Mohamed1,2 · Bader M. Alotaibi1