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Essential Oils: Brief Background and Uses

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Abstract

- Essential oils are aromatic essences extracted from natural sources and when they are concentrated they can be used in pharmaceutical, food applications, perfumery, sanitary and beauty products.
- Essential oils have been recognized as common food additives which can discover valuable applications in conservation of food commodities.
- Essential oils due to their better potencies and no side effects on human and environment can be utilized as substitutes to artificially synthesized chemical preservatives
- Plant essential oils are known to demonstrate repellent activities and therefore find valuable application in bug control.
- Essential oils can be consolidated into or coated onto edible films due to their antibacterial activities against contaminating microorganisms.

Essential Oils

Definition and concept

Essential oils are highly volatile, aromatic yields obtained from plants. Due to their volatility, they can easily be extracted by the method of steam distillation from different natural sources [1]. The oil secreting glands are located in fruits, flowers, seeds, wood, leaves, roots, barks and sometimes present throughout the body of the plant. The essential oils are named after their mother plant from where they are isolated and the odor also resembles the organ of the plant from where they are extracted. The aroma of these volatile yields is generally more concentrated in the essential oils. Different authors have defined essential oils, but a precise one is proposed by Schilcher, Hegnauer, and Cohn Richter and further concluded by Sonwa [2]. "Essential is a biochemical product or a combination of similar products, which are generated in cytoplasmic fluid and are located in intercellular space in the form of minute droplets. They are highly odorous and volatile in nature." They can be comprised of combinations of aromatic compounds or combinations of aromatic and non-aromatic compounds where an aromatic compound is defined as a "compound which possess chemical purity, volatile in ambient environment and possess odor which can please the aesthetic sense of the society". A more specific definition is proposed by International Organization for standardization (ISO) which states "extract procured from raw material of natural origin i.e. plant by steam distillation, by processes that involve mechanical extraction from the epicarp of citrus fruits or by physical extraction such as dry distillation following elution of the aqueous phase and may also have post extraction physical analysis provided that no changes in its composition takes place [2,3]. As mentioned earlier, essential oils are multiplex, comprising of various components, mostly of liquid state but may also comprise of solid particles. At an ambient temperature, these yields may appear colorless to light yellow in color when obtained currently, aromatic and are readily absorbed through the skin epidermis. These essential oils are low density fractions except for cinnamon, Sassafras and clove oils which have high density than water but are soluble in solvents such as diethyl ether, ethanol and miscible in vegetable oils, waxes and fats. Physical attributes of essential oils include high rotary strength and refraction index.

Historical context

The essential oils have been used for centuries for different purposes and regarded with great intrigue, albeit many their uses have been lost with time, it is by and large acknowledged that people have been extracting them from fragrant plants since the very beginning of humankind. Their application for various purposes are gradually changed and not only used for culinary purposes to

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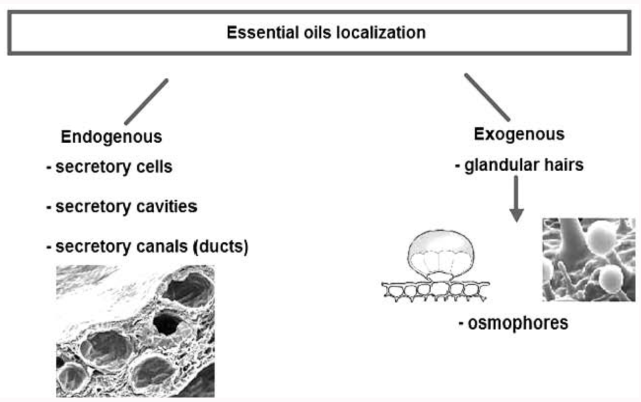

Figure 1: Presence of Essential oils in plant organs. Source: Preedy et al. [44].

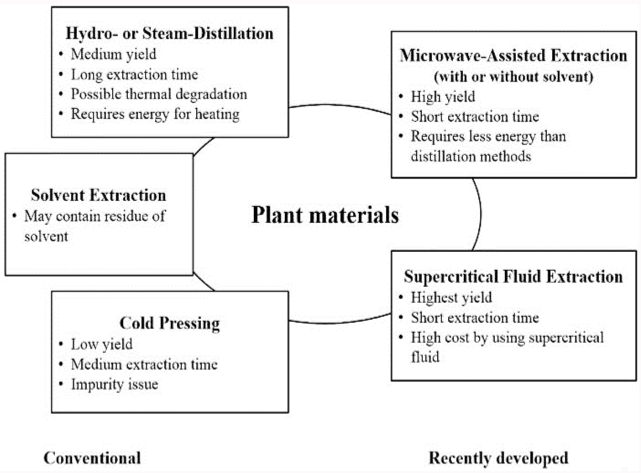

Figure 2: Different methods to extract essential oils adapted from Preedy et al. [44].

enhance the sensory appeal they also have been used for therapeutic purposes, yet in addition to their application in the fabrication of fragrances and beauty care products. Essential oils have been used by ancient Egyptians in medication, perfumery, and in the craft of planning bodies for entombment through preservation. In Asian region, the Vedas classified the employments of these aromatic essences for remedial and worship purposes. Indeed, through the ages, humans have utilized essential oils for different purposes, including religious uses, production of scents or for curing purposes against deadly ailments. The Phoenicians, Romans, Jews, Greeks traditions that were located around the Mediterranean basin as well as Aztecs and Mayas in the Americas all had a scent culture of incredible refinement [2]. After the fall of the Roman Empire and with the appearance of both Christian and Muslim human advancements, the craftsmanship and exploration of scent were conveyed to the Arab world, where it became further sophisticated. In the middle Ages, this information of aromas was taken back to Europe by the Crusaders coming back from the Holy Land and was created further by chemists and in the monasteries. Chemists tried to make the "elixir of life" keeping in mind the end goal to live inconclusively while the monasteries utilized essential oils for acquiring different therapeutic products to recuperate diverse maladies or for making perfumes and soap. Amid the Renaissance, the utilization of essential oils in perfumery and beautifying agents was spread out all throughout the world [2].

Variety in essential oils

Nearly 3000 diverse essential oils have been depicted. Of these, around 300 are utilized monetarily in the seasoning and scents advertise. In any case, the high diversity in the chemical composition of aromatic plants shows a possibly significant problem for the scent producing industry [4]. Therefore, much research has concentrated on the different factors adding to this assortment other than entirely genetic ones. For instance, researchers have depicted particular races of similar species, for instance, Melaleuca bracteata, that are rich in chief constituents, each of which produces an alternate essential oil with either methyl eugenol, methyl isoeugenol, and elemicin. Other fragrant plants, such as sweet flag (*Acorus calamus*), wormwood (*Artemisia absinthium*), sweet basil (*Ocimumbasilicum*) camphorwood (*Cinnamomumcamphora*), lemon balm (*Melissa officinalis*), thyme (*Thymus vulgaris*), peppermint (*Menthapiperita*), or tansy (*Tanacetum vulgare*) have been broadly considered and distinctive chemotypes and synthetic races have been depicted [5]. It has similarly been found that different variables can alter the chemical composition of essential oils, for example, atmosphere, precipitation, or geographic location of the plant.

Role and presence in vegetable kingdom

Essential oils are normally produced as secondary metabolites. In many instances, they are collected in non differentiated cells (such as in *Lauraceae*) or, on the other hand in secretary organs, for example, glandular hairs (such as in *Lamiaceae* and *Asteraceae*), secretary ducts (such as in schizolysigenous in *Rutaceae* or in schizogenous in *Myrtaceae*), or in cavities (such as in Conifers) (Figure 1). In minor cases, essential oils are not produced in the plant itself; however it is created through hydrolysis of a few compounds produced in the plant, similar to the case in garlic or valeriana [5,6]. Regarding their localization, essential oils can be produced in all parts of the plant, including the aerial organs, commonly comprised of leaves, blooms and stems (chamomile, peppermint, lavender); fruits (anise); bark (cinnamon); seeds (nutmeg); and in addition, in the rhizomes and radix (ginger and curcuma). The functions of essential oils in a plant are diversified. They are utilized for fertilization, protection component or may be employed as an irritant or repellant. Besides, there are distinctive speculations about their role as antioxidants in that they donate hydrogen in oxidative responses, particularly in photoreactions. They are moreover thought to be a shield for the plant from conceivable pathogenic attack by acting as antifungal or antimicrobial components [5].

Extraction of essential oils

Essential oils can be extracted by methods of steam distillation, steam and water distillation, or by steam distillation alone (Figure 1). These are the most conventional and regularly utilized strategies to isolate these aromatic essences. When the dissolvability of a specific essential oil in water is high, as in account of lavender, geranium or rose another procedure i.e. cohobation can be utilized. In this method, the loss of hydro soluble compounds can be prevented by returning the condensed water from the separator back to the still. Other forms for acquiring essential oils incorporate enfleurage and maceration with the recent systems employing extraction with supercritical liquids or solvents. Maceration can be utilized when the yield from distillation is low, while enfleurage and solvent extraction is reasonable for sensitive, costly and thermally unstable materials [7]. Generally, essential oils are acquired through water distillation

Food Categories	Essential Oil	Combined Use with	Activity against
Meat	Thyme oil		Acid bacteria Enterobacteriaceae *Pseudomonas*
	Oregano oil		Acid bacteria Enterobacteriaceae *Pseudomonas*
	Oregano or thyme oil	Nisin	*Listeria* sp. Gram negative Gram positive
	Oregano and thyme oils	Soy edible films	*S. aureus*, *E. coli* *Pseudomonas* spp. Coliform bacteria
	Inula graveolens, *Laurus nobilis*, *Pistacia lentiscus*, and *S. montana*	MAP	Campylobacte
	Chitosan oil		*Listeria monocytogenes* *Escherichia coli*
	Rosemary oil		*Clostridium botulinum*
Fish	Clove oil		*Listeria monocytogenes Salmonella enteritidis* *Escherichia coli* *Staphylococcus aureus*
	Fennel oil		
	Lavender oil		
	Thyme oil		
	Herb-of-the-cross oil		
	Pine oil		
	Rosemary oil		
	Citosan oil	Sunflower protein films	*Pseudomonas fluorescens* *Shewanella putrefaciens* *Photobacterium phosphoreum* *Listeria innocua*, *Escherichia coli*, *Lactobacillus acidophilus*
Dairy product	Clove oil		*Salmonella enteritidis*
	Clove and cinnamon oils	Vanillin	*Listeria monocytogenes*, *Escherichia coli*
Juice	Mixture of terpenes and D-limonene nanoencapsulated		*Saccharomyces cerevisiae*, *Escherichia coli* *Lactobacillus delbrueckii*

Figure 3: Antimicrobial potential of EOs. Adapted from Preedy et al. [44].

or steam distillation from various organs of the plant, including the entire plant or simply the fruits, wood, leaves, roots, bark, or seeds [1]. The portions of plants collected for extraction purposes can be freshly obtained, partially dried or dehydrated but in the case of flowers they must be freshly picked. If the method of steam distillation is used to obtain these aromatic essences, the nature of extracted compounds will always be volatile. If solvents are utilized for isolation purposes, then the chemical assortment will differ from similar essential oil got through distillation. In addition, if the plant material is incubated with water at high temperatures prior to extraction phase, the composition of essential oil will also differ significantly. Whenever water and plant material are kept in different systems and the water vapor goes through the plant material, the contact is short and the oil can be gathered only a couple of minutes in the initial stages of the procedure [7]. One other option to distillation that maintains a minor synthetic change in the extracted product is supercritical CO2 extraction. This process tends to leave labile mixes and an extensive variety of different standards unaltered, for instance, when purification is done by using this technique, the extracted yield may contain flavonoids of non-volatile nature [8]. In similar manner, when essential oil is obtained by solvent extraction, including enfleurage, the extractive fluid may dissolve mixes for example, resinoids and other nonvolatile fractions. Diverse outcomes can be obtained with different procedures, for example, cold squeezing or crushing of the external peel of mainly citrus fruits in presses subsequently decanting or centrifuging the oils to isolate the plant material and the fluid remains. In every one of these cases, the chemical composition of the essential oils is very not quite the same as that obtained through distillation [7].

Applications of essential oils

The utilization of essential oils is to a great degree assorted relying upon the source, quality, extraction strategy, and so on. Essential oils have demonstrated modern applications in the fabricate of fragrances, beautifying agents, soaps, shampoos, or cleaning gels. Another fascinating part of these oils is their potential as medicines in aroma based therapies or as carriers for drug delivery. Another major utilization of essential oils is in the agro food business, both for creating refreshments and for enhancing sensorial properties of food items.

Beauty care products: The utilization of essential oils in the beauty care products, detergent, soap and scent industry is of great concern from a financial point of view. The generation of essential oils for preparation of perfumes and scents has expanded enormously on a global level and simultaneously collection of these aromatic plants. Salvia, lavender and thyme species are highly consumed to produce these aromatic yields. Sufficient determination of the crude source material and method employed for the extraction are fundamental components for enhancing the nature of the volatile yields.

Pharmaceutic and therapeutics: Essential oils are utilized as a part of pharmaceutics for their potential as therapeutic agents [9,10]. This is particularly the instance of the essential oils from peppermint (*Menthapiperita*), sage (*Salvia officinalis*), anise (*P. anisum*), eucalyptus (*E. globulus*), clove (*S. aromaticum*), and tea tree (*M. alternifolia*). These oils are utilized as an expectorant for treating bronchitis and cough (eucalyptus essential oil), as antibacterial agents (sage, clove and tea tree oil), as a decongestant of the respiratory tract (peppermint oil), and as a carminative (anise oil). Moreover, clove oil is utilized as a part of dentistry for its antimicrobial and pain-relieving properties while tea tree oil is utilized in the field of dermatology (antiacne drug) as it possesses antimicrobial properties against Gram-positive microbes [11]. In pharmaceutics, essential oils are used to enhance sensory attributes of pharmaceutical drugs. The prime application of essential oils in pharmaceutics is aromatherapy. Different strategies can be utilized to administer essential oils isolated from different plant sources. The term "aromatherapy" was coined by Gattefossé in the 1920s and was restored by Maury in the 1960s. Since the 1980s, its prominence has expanded relentlessly. In current times, it is genuinely entrenched in Germany, New Zealand, Australia, Canada, France, Switzerland, the United States, and United Kingdom [12]. The most well-known application strategy for essential oils is local application of these oils along with some carrier oils after being diluted to a concentration. They can likewise be breathed in the steaming water after addition of few drops or by methods for a humidifier or atomizer. Moreover, they can be used as balms, compresses and creams. In any case, oral utilization of essential oils through encapsulation or other customized discharge techniques has been presented as a successful strategy for getting the helpful impacts of these essences [13]. They can also be used as extract infusions in the form of tea which is considered more exact dose while preventing unwanted impact. However, it is conceivable that the harmfulness of essential oils might be higher when taken by this method [14].

Agro food: Essential oils are utilized as a part of a wide range of food products, for example, confectionery sodas, and alcoholic drinks. Apart from being consumed as a seasoning material, they are also utilized as a part of agriculture and food industry for their antimicrobial, antiviral, antifungal, insecticidal, nematocidal, and anticancer attributes [15,16]. Due to these reasons, their use as preservatives in food and as an agent has been indicated [17]. Numerous essential oils have antibacterial as well as anti oxidative

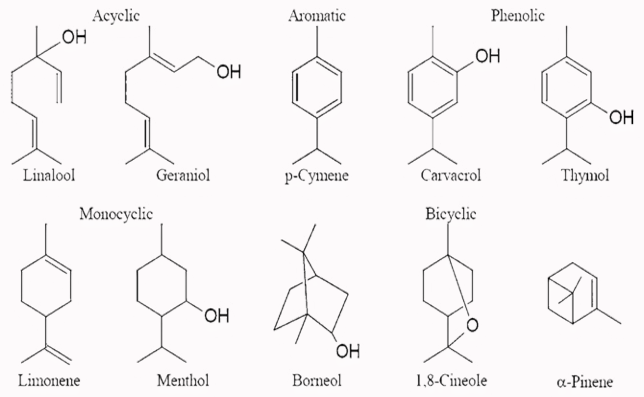

Figure 4: Major terpenes that have pesticidal efficacies. Adapted from Preedy et al. [44].

properties [18,19], yet their application as additives in food items requires a detailed learning of their properties, including the inhibition of the microorganisms on target, the particular method of activity, their antibacterial effectiveness, and the possible interaction impact on their antibacterial attributes with food components [1].

Essential oil application in food preservation: As this study is entirely based on the food preservation technique using novel edible coating formulations therefore, thorough understanding is required to comprehend mechanisms involved in food packaging.

Background: There is a leading interest for the utilization of new techniques for maintaining safety of food items and to have a native characteristic and 'Green' outlook. One such plausibility is the utilization of Essential Oils (EOs) as food additives to preserve food quality and safety [4]. Enhancing the food storage life, while guaranteeing its quality and safety, is a focal interest of the agro-food industry and government organizations. Storage life has been characterized as the time duration amid which the food item will stay unaltered; retain sensorial properties, physical, biochemical, microbiological, and functional attributes; and conform to any name affirmation of dietary information when stored under the conditions mentioned on the label. In this way, the definition of a preservative can be stated as a compound that maintain or elongate the storage life of a food product. Essential oils can be easily characterized as food preservatives due to their versatile biological activities.

Preservative attributes of Eos: EOs are normally described by a strong scent and these blends comprise of more than 200 constituents who can be characterized fundamentally into volatile and non-volatile components [20]. Around 90% to 95% of the EO is comprised of the volatile components and this comprises of sesquiterpene hydrocarbons, monoterpenes and their oxygenated fractions, alongside aliphatic aldehydes, esters and alcohols. The nonvolatile components, nonetheless, constitutes around 5% to 10% of the entire oil, which for the most part contains unsaturated fats, waxes, sterols, cumarines, hydrocarbons, carotenoids and flavonoids [21,22].

The phenolic constituents as indicated by are significantly contributors of antibacterial properties [4]. These phenolic compounds contain at least one aromatic ring containing one or more hydroxyl groups and are produced as secondary metabolites by plants [23]. Phenolic compounds are mainly biosynthesized from aromatic amino acids by means of the shikimate pathway. The importance of this pathway is that under ordinary growth conditions, 20% of the carbon fixed by plants moves through this biosynthetic pathway. The aromatic amino acids Phenylalanine, and tryptophan, tyrosine is biosynthesized through this pathway and are later used for building up of proteins or converted by means of phenylpropanoid metabolic pathway to secondary metabolites, for example, phenolic compounds [24]. Phenolic compounds are subdivided on the basis of number of carbon atoms attached to the basic framework of phenolics [23]. Antibacterial activities of essential oils were observed by Burt [4]. The antibacterial attributes of thyme EOs for example, have been accounted for to be for the most part contributed by carvacrol and thymol, which are the phenolic fractions of the oil. Carvacrol and thymol are structurally alike with a minor difference is the attachment of hydroxyl group to phenolic ring in thymol. The two substances seem to alter the cell membrane integrity [25]. Carvacrol and thymol can break down the outer envelope of Gram negative microbes, leading in diffusion of lipopolysaccharides and alleviating the porousness of the cytoplasmic layer to Adenosine Triphosphate (ATP). This mechanism was shown to be unaltered by the presence of magnesium chloride ions [26]. Minor fractions of EOs are involved in the synergistic activities with other fractions thereby playing an important role in the biological activities of EOs. Nevertheless, phenolic compounds are more potent to display antibacterial actions. These terpene phenols are joined to the amine and hydroxylamine groups of the proteins of the bacterial cell membrane, consequently altering their permeability consequently cell lysis [27]. Olmedo, Nepote, & Grosso assessed the impact of oregano and rosemary EOs on the oxidative and fermentative qualities of seasoned cheddar with cream cheddar base [28]. They concluded that oregano EO possessed anti lipid oxidation properties. Goni showed that Gram negative bacteria (*Escherichia coli*, *Salmonella choleraesuis*, *Pseudomonas aeruginosa* and *Yersinia enterocolitica*) and four Gram-positive bacteria (*Bacillus cereus*, *Staphylococcus aureus*, *Listeria monocytogenes* and *Enterococcus faecalis*) can be inhibited by the combined vapors of rosemary and oregano [29]. This study confirmed the inhibitory effect of EOs in vapor phase for the first time. Bounatirou observed the biological activities of EOs isolated from aerial parts of Tunisian Thymus capitatus Hoff. et Link at different maturity stages and collected from different geographical locations [30]. Higher antibacterial action was seen with the blossoming and the post-flowering stage EOs when the activities of these EOs were compared with synthetic antibiotics. Antimicrobial activity of different EOs against food pathogens where concluded in Figure 2.

Pest repellant potency: Food items, for example, fruits, stored grains and other cellulose rich materials are highly contaminated by different vermin, for the most part arthropods. To prevent the food from being infested by these pests there is a dire need to preserve such commodities. The utilization of chemicals to control the pests raises a few human health issues. Different options being investigated is the utilization of compounds isolated from natural sources that have great adequacy and have no injurious effect on environment. EOs is among these chemicals to be used as repellants isolated from natural reserves and have a great deal of efficacy. In connection to human medical problems, the United States Environmental Protection Agency has affirmed the adequacy of a few EOs and therefore enlisted citrus EO, lemon EO and eucalyptus EOs as insect repellents to be used locally. Compounds derived from natural sources have shown to possess high potency, no toxic effects on humans and subsequently opted by consumers [31]. However, these decoctions may not always be a safer alternative as these compounds needed to be assessed by different

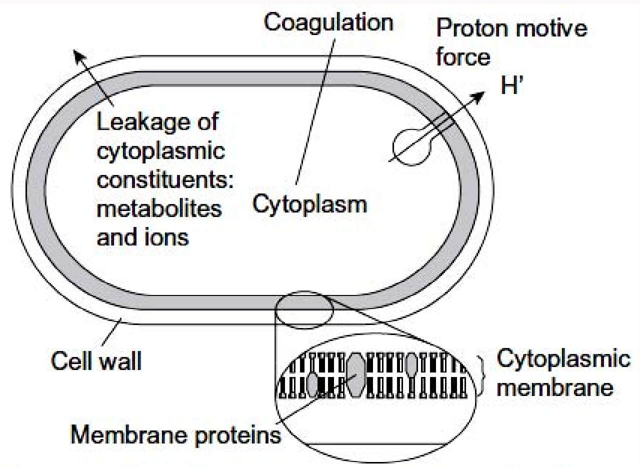

Figure 5: Mechanism of action of essential oils on microbial cell. Adapted from Sadaka et al. [33].

assays which check their safety and efficacy. The broad investigation demonstrates that EOs from plant and their individual metabolites have shown ideal potential for repelling bugs, as well as different sorts of arthropods (Figure 3). The activity of these EOs is comparable to those exhibited by synthetic repellants when these EOs are mixed with fixative chemicals which overcome the problem of volatility of EOs and losing their function.

Use as antibacterial packaging: EOs have been affirmed to be of incredible significance in the control of microbial growth. As a rule, they are molded to target particular microorganisms so as to give higher bactericidal activity and therefore sustain quality and storage life of food products. EOs has shown to be an active ingredient for food safety and packaging [32]. The interest for the utilization of antibacterial packaging as an active packaging is on the expansion and due to the consumer demand for minimally processed foods are increasing these packaging materials can be of great use [33]. In such manner, EOs and all the more particularly their bioactive properties such as antibacterial, antiviral, antifungal, insecticidal, and anti oxidative attributes [34-36]. The antibacterial potential of EOs in food systems is multi-dimensional factor and involves a variety of factors to contribute to the antibacterial efficacy (Figure 4).

Active component of food packaging material: Edible coatings are developments in the field of food safety and hygiene. These coatings are made up of complex carbohydrates, lipids and proteins. Despite the fact that protein and polysaccharide films possess better mechanical attributes, they have a poor conductivity to water molecules as they are hydrophilic in nature (Figure 5). The addition of Sodium Caseinate (SC) to these films can greatly improve their water barrier properties. SC is yielded as an end product of acid precipitation of casein which is soluble in water [37]. These films have an advantage of having nutritional properties as well as they are well suited for food preservation due to their sensory attributes. In such manner, effectively enhanced the appropriateness of water vapor penetrability of the SC films for food items by incorporating oleic acid and beeswax [38]. These films can further be improved by the addition of EOs such as Ginger and cinnamon oil. Atarés, De Jesús, Talens, & Chiralt [39] described SC-based films fused with cinnamon or ginger EO and confirmed that cinnamon oil remained homogeneously coordinated in the SC lattice, offering ascend to films with normal surfaces, yet extensively influenced the optical properties of SC films [40-44]. Because of the collection of lipids amid drying, ginger oil caused a loss in smooth surface of films and lost gleam. The reason behind these undesirable properties is low oxygen permeability under low humid conditions [45].

References

1. Hyldgaard M, Mygind T, Meyer RL. Essential oils in food preservation: mode of action, synergies, and interactions with food matrix components. Front Microbiol. 2012;3:12.
2. Mekem Sonwa M. Isolation and structure elucidation of essential oil constituents: comparative study of the oils of Cyperus alopecuroides, Cyperus papyrus, and Cyperus rotundus. 2000.
3. Turek C, Stintzing FC. Stability of essential oils: A review. Comprehensive Reviews in Food Science and Food Safety. 2013;12(1):40-53.
4. Burt S. Essential oils: their antibacterial properties and potential applications in foods-a review. Int J Food Microbiol. 2004;94(3):223-53.
5. Evans WC. Trease and Evans' Pharmacognosy E-Book. Elsevier Health Sciences. 2009.
6. Franz C, Novak J. Sources of Essential Oils. Handbook of Essential Oils: science, Technology, and Applications. 2009.
7. Chamorro ER, Zambón SN, Morales WG, Sequeira AF, Velasco GA. Study of the chemical composition of essential oils by gas chromatography. Gas chromatography in Plant Science, Wine Technology, Toxicology and Some Specific Applications. 2012.
8. Herzi N, Bouajila J, Camy S, Cazaux S, Romdhane M, Condoret JS. Comparison between supercritical CO2 extraction and hydrodistillation for two species of eucalyptus: yield, chemical composition, and antioxidant activity. J food sci.2013;78(5).
9. Edris AE. Pharmaceutical and therapeutic potentials of essential oils and their individual volatile constituents: a review. Phytother Res. 2007;21(4):308-23.
10. Lawless J. The Encyclopedia of essential oils: the complete guide to the use of aromatic oils in aromatherapy, herbalism, health, and well being: Conari Press. 2013.
11. Buchbauer G. Biological activities of essential oils. Handbook of essential oils: Science, technology, and applications. 2009;235-280.
12. Koroch AR, Juliani HR, Zygadlo JA. Bioactivity of essential oils and their components. Flavours and fragrances. 2007;87-115.
13. Boehm K, Büssing A, Ostermann T. Aromatherapy as an adjuvant treatment in cancer care–a descriptive systematic review. Afr J Tradit Complement Altern Med. 2012;9(4):503-18.
14. Karlsen J. Encapsulation and other programmed release techniques for essential oils and volatile terpenes. Handbook of essential oils. CRC, Taylor and Francis Group, Boca Raton, FL. 855-62.
15. Adorjan B, Buchbauer G. Biological properties of essential oils: an updated review. Flavour and Fragrance Journal. 2010;25(6):407-26.
16. Adlard ERK. Hüsnü Can Başer and Gerhard Buchbauer (Eds.): Handbook of Essential Oils. Science, Technology and Applications. Chromatographia. 2016;79(11-12):791.
17. Lopez-Reyes JG, Spadaro D, Prelle A, Garibaldi A, Gullino ML. Efficacy of plant essential oils on postharvest control of rots caused by fungi on different stone fruits in vivo. J Food prot. 2013;76(4):631-9.
18. Lang G, Buchbaue 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.
19. Dandlen SA, Lima AS, Mendes MD, Miguel MG, Faleiro ML, Sousa MJ, et al. Antioxidant activity of six Portuguese thyme species essential oils. Flavour and Fragrance Journal. 2010;25(3):150-5.

20. Jalali-Heravi M, Parastar H, Sereshti H. Towards obtaining more information from gas chromatography-mass spectrometric data of essential oils: an overview of mean field independent component analysis. J Chromatogr A. 2010;1217(29):4850-61.

21. Basile A, Jiménez-Carmona MM, Clifford AA. Extraction of rosemary by superheated water. Journal of Agricultural and Food Chemistry. 1998;46(12):5205-9.

22. De Castro ML, Jimenez-Carmona M, Fernandez-Perez V. Towards more rational techniques for the isolation of valuable essential oils from plants. TrAC Trends in Analytical Chemistry. 1999;18(11):708-16.

23. Michalak A. Phenolic compounds and their antioxidant activity in plants growing under heavy metal stress. Polish J of Environ Stud. 2006;15(4):523-30.

24. Dıaz J, Bernal A, Pomar F, Merino F. Induction of shikimate dehydrogenase and peroxidase in pepper (Capsicum annuum L.) seedlings in response to copper stress and its relation to lignification. Plant Science. 2001;161(1):179-88.

25. Lambert R, Skandamis PN, Coote PJ, Nychas GJ. A study of the minimum inhibitory concentration and mode of action of oregano essential oil, thymol and carvacrol. J Appl Microbiol. 2001;91(3):453-62.

26. Helander IM, Alakomi HL, Latva-Kal K, Mattila-Sandholm T, Pol I, Smid E, et al. Characterization of the Action of Selected Essential Oil Components On Gram-Negative Bacteria. Journal of Agricultural and Food Chemistry. 1998;46(9):3590-5.

27. Juven B, Kanner J, Schved F, Weisslowicz H. Factors that interact with the antibacterial action of thyme essential oil and its active constituents. J Appl Bacteriol. 1994;76(6):626-31.

28. Olmedo RH, Nepote V, Grosso NR. Preservation of sensory and chemical properties in flavoured cheese prepared with cream cheese base using oregano and rosemary essential oils. LWT-Food Science and Technology. 2013;53(2):409-17.

29. Goni P, López P, Sánchez C, Gómez-Lus R, Becerril R, Nerín C. Antimicrobial activity in the vapour phase of a combination of cinnamon and clove essential oils. Food chemistry. 2009;116(4):982-9.

30. Bounatirou S, Smiti S, Miguel MG, Faleiro L, Rejeb MN, Neffati M, et al. Chemical composition, antioxidant and antibacterial activities of the essential oils isolated from Tunisian Thymus capitatus Hoff. et Link. Food Chemistry. 2007;105(1):146-55.

31. Katz TM, Miller JH, Hebert AA. Insect repellents: historical perspectives and new developments. JAAD. 2008;58(5):865-71.

32. Day B. Extension of shelf-life of chilled foods. European Food and Drink Review. 1989;4:47-56.

33. Sadaka F, Nguimjeu C, Brachais CH, Vroman I, Tighzert L, Couvercelle JP. WITHDRAWN: Review on antimicrobial packaging containing essential oils and their active biomolecules. Innovative Food Science & Emerging Technologies. 2014.

34. Sökmen M, Serkedjieva J, Daferera D, Gulluce M, Polissiou M, Tepe B, et al. In vitro antioxidant, antimicrobial, and antiviral activities of the essential oil and various extracts from herbal parts and callus cultures of Origanum acutidens. J Agric Food Chem. 2004;52(11), 3309-12.

35. Kordali S, Kotan R, Mavi A, Cakir A, Ala A, Yildirim A. Determination of the chemical composition and antioxidant activity of the essential oil of Artemisia dracunculus and of the antifungal and antibacterial activities of Turkish Artemisia absinthium, A. dracunculus, Artemisia santonicum, and Artemisia spicigera essential oils. J Agric Food Chem. 2005;53(24):9452-8.

36. Regnault-Roger C, Hamraoui A, Holeman M, Theron E, Pinel R. Insecticidal effect of essential oils from mediterranean plants upon Acanthoscelides Obtectus Say (Coleoptera, Bruchidae), a pest of kidney bean (Phaseolus vulgaris L.). J Chem Ecol. 1993;19(6):1233-44.

37. Audic JL, Chaufer B. Influence of plasticizers and crosslinking on the properties of biodegradable films made from sodium caseinate. European Polymer Journal. 2005;41(8):1934-42.

38. Fabra MJ, Talens P, Chiralt A. Tensile properties and water vapor permeability of sodium caseinate films containing oleic acid–beeswax mixtures. Journal of Food Engineering. 2008;85(3):393-400.

39. Atarés L, De Jesús C, Talens P, Chiralt A. Characterization of SPI-based edible films incorporated with cinnamon or ginger essential oils. Journal of Food Engineering. 2010;99(3):384-91.

40. Baser KHC, Buchbauer G. Handbook of essential oils: science, technology, and applications. CRC Press. 2015;1128.

41. Filippi JJ, Belhassen E, Baldovini N, Brevard H, Meierhenrich UJ. Qualitative and quantitative analysis of vetiver essential oils by comprehensive two-dimensional gas chromatography and comprehensive two-dimensional gas chromatography/mass spectrometry. J Chromatogr A. 2013;1288:127-48.

42. Khan MA. Chemical composition and medicinal properties of Nigella sativa Linn. Inflammopharmacology. 1999;7(1):15-35.

43. Pellati F, Orlandini G, Leeuwen KA, Anesin G, Bertelli D, Paolini M, et al. Gas chromatography combined with mass spectrometry, flame ionization detection and elemental analyzer/isotope ratio mass spectrometry for characterizing and detecting the authenticity of commercial essential oils of Rosa damascena Mill. Rapid Commun Mass Spectrom. 2013;27(5), 591-602.

44. Preedy VR. Essential oils in food preservation, flavor and safety. 2015.

45. Viuda-Martos M, Ruíz-Navajas Y, Fernández-López J, Pérez-Álvarez JA. Chemical composition of the essential oils obtained from some spices widely used in Mediterranean region. Acta Chimica Slovenica. 2007;54(4):921-6.