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Lavandula Essential Oils: Applications in Medical, Pharmaceutical, Food, and Cosmetic Industries

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Abstract

The global market for essential oils has risen steadily over the past few years and is expected to reach a round $ 7.5 billion a year by 2018. Lavanda (*Lavandula*, the *Lamiaceae* family) contributes significantly to this market, producing about 1500 tons of essential oils that are mainly used in cosmetics, personal care products and medicines. The objective of the exhaustive study was to research the recent literature on these preparations, which also shows that these oils can have applications in food preservation and pest control, a mong others. The material used was a substantial part of the current research, which we analyzed, focusing on assessing the biological activities of essential oils of lavender. The method was to describe the medic inal and pharmaceutical properties of lavender species, mainly due to their essential oils, especially the prin cipal constituents of the essential oil: linalool and linalyl acetate, although certain activities were attributed to phenolic compounds. In addition, we have demonstrated that there is evidence that certain major and mi nor constituents of the essential oil act synergistically to produce various effects. The results recommen d the potential use of these oils in traditional and complementary medicine, food systems, cosmetic formula tions and perfumes as well as in insecticides and fungicides. In conclusion, this paper examines recent adva nces in these areas and highlights the current and future implications for these valuable economic and medi cal plants.

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1. Introduction

Although native to the Mediterranean region lavenders are commercially grown around the world (e.g., in B ulgaria, France, Spain, Portugal, the United Kingdom, China, Australia, and the United States), primarily for their essential oils [1].

Lavender essential oils have been used in cosmetics, and medicinal preparations since the Greek and Roma n era, and are now being considered for use in areas such as alternative medicine, food preservation, and pe st control, among others.

Most studies have focused on the two main constituents of most lavender essential oils (linalool and linalyl acetate), although other less abundant essential oil constituents (e.g., camphor, 1,8-cineole, carvacrol, etc.) h ave also been evaluated.

From the existing 39 lavender species, the most commonly cultivated and researched species include *L . angustifolia*, *L.latifolia*, and *L. x intermedia*. A significant amount of research also being conducted on *L . stoechas* and *L. luisieri* [2, 3].

Numerous cultivars have arisen from standard breeding experiments [2]. More recently, research efforts ha ve focused on increasing oil yield and quality in these plants through metabolic engineering and other mol ecular techniques [4-6].

With a 2018 projected global market value of $7.47 USD and an increase in demand for natural products, the essential oil industry has become increasingly important with a 5.93% Compound Annual Growth Ra te (CAGR) since 2013 [7].

***Lavandula* essential oils contribute largely to this growing industry with approximately 1500 tons produced annually for use in a variety of settings.**

In 2013, Bulgaria was the top oil producer, generating 100 tons of oil from 3700 hectares and France in sec ond with oil production of 40 tons per year from 3500 hectares of plants [8].

2. Cultivation and Selection of Lavenders

Lavenders originate from the Mediterranean region, and today, are diversified and distributed around the world. Although limited reports are available on agronomic practices, a variety of lavender species grow we ll in a wide range of climatic conditions, most preferably in full sun-light and well- drained soils with little organic matter [2, 3].

Despite the fact that some lavender species can tolerate certain climatic stresses (e.g. heat, drought, wind & frost), sufficient agronomic practices, such as fertilizer, irrigation, pruning, weeds control a nd others, are required for optimum establishment and maximum commercial production [2, 3, 9, 10] .

Most of the lavender species reproduce by seeds and/or clonal reproduction mechanisms; however, due to plant uniformity for large-scale production of essential oil, cut flowers and pot plants, and other technicaliti es, the majority of lavenders growers and gardener nurseries around the globe prefer clones rather than seed derived seedlings [2, 3, 10].

This approach is also useful for propagation of sterile hybrid lavenders, e.g. *L. x.intermedia*, which lack fertile seeds. Some lavender species, e.g. *L. angustifolia* varieties- Hidcote and Munstead, are propagated b y both seeds and clones [3]. In addition, variation in different traits, e.g. plant growth habit, flower color a nd essential oil composition, can be observed in plants originating from seeds, which eventually influence the commercial quality, uniformity and harvesting periods [3, 10]. From the over 39 lavender species identified, only a few, in particular *L. angustifolia*, *L. x intermedia* and *L. latifolia,* have been widely used for commercial cultivation [2, 3, 9, 11].

The suitable cultivars have so far been chosen mainly based on their flowering season (early, mid or late season), oil yield and oil quality. In this context, most *L. x intermedia* cultivars (e.g. Grosso) produces large biomass with high yields of flowers and oils which can be the preferable species for maximum production. *L. angustifolia* cultivars (e.g. Hidcote) consist of short-stemmed flowers producing low biomass with low yields of flowers and oils, but are well known by the high quality of the oils [2, 3, 11].

It should be noted that the phenotypic traits and biochemical compositions of the cultivars can be influenced by several environmental cues, including soil type, temperature and light [12]. Identification techniques for lavender species/cultivars are mostly limited to morphological traits and metabolite profiling in most commercial farms and nurseries. Recently, good progress has been started on the development of markers such as microsatellites and metabolomic markers for the identification of lavenders [13, 14].

3. Chemical Composition of Lavender Extracts

Lavenders are especially known for their essential oil (EO), which is comprised of over 50 mono- and sesquiterpene constituents. The main EO constituents include linalool, linalyl acetate, borneol, and 1,8-cineole (Fig. 1) [15, 2]. The exact constituent abundance (ie. EO composition) is primarily determined by the species, although plant health, climatic season differences, harvest time, and post- harvest processing can also have effects on oil composition, as well as essential oil extraction method used also affect essential oil composition [16, 17-20].

All *Lavandula* species also accumulate phenolic acids, which contribute to the bioactivity of aqueous lavender extracts. The most prominent phenolic acids reported in *Lavandula* include ferulic acid, rosmarinic acid, p-coumaric acid, caffeic acid and 2-Oglucosilcoumaric acid [25, 29, 30]. The phenolic compounds of lavender have been primarily investigated for their antioxidant effects, demonstrating a positive correlation of content of phenolic acids to antioxidant levels [31].

4. Biosynthesis of Lavenders Essential Oil Constituents

There Lavenders produce and store EO in specialized structures known as glandular trichomes, or oil glands [32]. In these structures six to eight secretory cells are specialized to produce and secrete EO constituents (a mixture of mono- and sesquiterpenes) into a subcuticular storage cavity [33, 34].

Like other terpenoids, lavender EO constituents are derived from isopentenyl diphosphate (IPP) and its isomer dimethylallyl diphosphate (DMAPP) derived from both the Mevalonate (MVA) or cytosolic pathway, and the 2-Cmethyl-D-erythritol 4-phosphate (MEP) or plastidial pathway of terpenoid metabolism [32, 34-38].

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The MVA pathway predominantly found in animals and fungi as well as in the cytoplasm of phototropic organisms. Precursors produced through this pathway are mainly converted to FPP to synthesize sesquiterpenes, and triterpenes [39-42]. The MEP pathway, present in most bacteria and in plant chloroplasts, provides precursors for the biosynthesis of GPP and GGPP that are ultimately used to produce monoterpenes and diterpenes, respectively [43-45].

Mono- and sesquiterpenes are derived from GPP and FPP, respectively, by the activity of various terpene synthases (sometimes called cyclases) [43]. Some monoterpenes, such as camphor and linalool acetate, are further modified through acetylation, oxidation or, reduction reactions.

Camphor is produced from borneol by the action of a short chain alcohol dehydrogenase and linalool acetate is produced from linalool by the linalool acetyltransferase enzyme [46, 47]. Two intermediate cationic forms, such as farnesyl cation and its isomer nerolidyl cation, are produced by sesquiterpene synthases before any rearrangement occurs for stable compounds similar to monoterpene biosynthesis [43, 48].

5. Lavandula Product Availability

The versatility and therapeutic benefits of lavenders have led to its application in a variety of products. These products are produced and available worldwide from home businesses and smallscale hobby farms to large scale farms with mass essential oil production for industry use.

Products containing lavenders and their essential oils are distributed globally in boutiques, grocery stores, farmers's markets, home stores and in online stores. Lavender essential oils and aqueous extracts are commonly used in a variety of bath and body products such as lotions, soaps and bath gels, in skin care items including cleansers, toners, moisturizers, masks, and facial creams, and in a variety of household and culinary products. Main methods of administration include topical and inhalation, although ingestion is common with various culinary products and medications.

6. Applications of *Lavandula* Essential Oils in Aromatherapy

Aromatherapy, refers the medicinal use of plant essential oils and fragrant extracts in a variety of clinical settings, including mood augmentation, treatment and prevention of disease and disease symptoms, sleep and cognitive improvement, and pain relief [49, 50, 51]. Administration by inhalation and massage are the most common methods of treatment used in aromatherapy.

Lavandula **essential oils, inhaled or massaged into the skin, are absorbed and enter the bloodstream, with linalool and linalyl acetate constituents apparent in the blood, thus implicating that benefits of aromatherapy may be due to essential oil constituents entering the bloodstream** [52].

Aromatherapy has become increasingly popular as naturopathic and complementary medicine become more prevalent, and although there is evidence for positive effects of aromatherapy in some cases, further research is required to determine the efficacy of the essential oil in more specific scenarios [50]. As such, due to its analgesic properties, lavender essential oil aromatherapy has been studied in a wide array of settings and has proven to have some promising positive effects.

7. Lavandula Essential Oils in the Cosmetic Industry

Essential oils have been commonly used in cosmetics for their pleasing aromas in products such as moisturizers, sunscreen, lotions, shampoos, bath and body products, soaps and perfumes, for centuries [113].

Recent evidence suggests that essential oils may have other functions in cosmetics as well [114].

> **Several studies have shown that *Lavandula* essential oils have efficacy as natural preservatives in cosmetics and personal care products. Due to the nutrient-rich nature of cosmetics, which commonly contain ingredients such as lipids, polysaccharides, amino acids, proteins, alcohol, glucosides, peptides, esteroids, and vitamins, increased microbial growth of a wide array of pathogens is evident in such products [115].**

Microbial growth in topical cosmetics presents danger to consumers due to transmission of pathogens, as well as product spoilage and quality issues due to pathogen- produced metabolites [116]. As such, chemical preservatives are necessary and widely used in cosmetics. Chemical preservatives are a common cause of allergic reactions to cosmetic users; however, they are necessary to preserve product quality and integrity throughout the manufacturing process and in maintaining product shelf life. Many preservatives which are widely used in cosmetics, such as parabens, can have adverse effects on human health, thus emphasizing the need for natural preservatives as alternatives [117]. Due to the increasing demand for more natural products with less chemical preservatives and decreased side effects, research for alternatives continues.

Lavandula essential oils have the potential for use in cosmetics as a natural preservative, possibly replacing synthetic preservatives; they may also be used in combination with other preserving agents to synergistically reduce the amount of harmful chemicals used in cosmetics [114, 118, 119]. For example, *Lavandula* essential oils have shown antimicrobial effects in reducing oral malodor, preservative effects in washing liquid and soft body balms, as well as in aqueous creams [120-122].

The use of mircoencapsulation techniques of these oils is common, and has proven to be effective in lengthening the effects of the essential oils by protecting ingredients from heat, light, and moisture and preventing volatilization of the aromatics [114, 123]. Hydrosols of *L. angustifolia* and other *Lavandula* species have also proven to have potential as cosmetic preservative additives as they display antioxidant, antimicrobial and antifungal properties, they require no dilution, their use would be economically and environmentally favorable, and as such, they would be effective in maintaining cosmetic microbiological integrity and shelf life [124, 8].

When utilizing oil in products intended for topical use, however, important considerations of the amount of essential oil must be considered as high levels of essential oil will be effective in terms of antimicrobial activity, but increases the risk of skin irritation and an overpowering aroma [121]. Although *Lavandula* essential oils have shown promise as natural cosmetic additives, adverse side effects from usage have also been observed.

Previous studies have shown extracts of *L. officinalis* and other plants to cause contact allergies in patients with cosmetic dermatitis [125, 126]. Pure linalool and linalyl acetate, which are present in a variety of cosmetic products, have specifically been shown to cause contact dermatitis [127].

These constituents, which are commonly used for their aroma, have the tendency to oxidize upon air ex posure, which transforms them from weak sensitizing agents to moderate sensitizing agents capable of causi ng frequent dermal contact reactions as strong fragrance allergens [128, 129]. As such, although *Lavandula* essential oils have potential for use in cosmetics, stringent ingredient labelling and allergen information should be available to consumers to prevent allergic reactions.

8. Conclusions

The present review focuses on recent advances in the study of *Lavandula* essential oils and phenolic c ompounds. Topics addressed include the commercial applications of *Lavandula* essential oils in the pharma ceutical and cosmetic industries as well as medicinal applications of *Lavandula* essential oils as antifunga ls, antioxidants, anti-inflammatory agents and their use in aromatherapy.

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