Essential Oils as Antimicrobials

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Essential oil is a term reserved for those compounds that are defined by the International Organization for Standardization (ISO) in their ISO 9235. These kinds of compounds are complex mixtures originated from the secondary metabolism, produced by the glandular trichomes, and in different secretory structures. They can be composed by terpenes, associated or not to other components, generally volatile and that provides an odor to the vegetable. These compounds have (with exceptions) a density lower than water density and are usually presented in liquid form. Besides, essential oils are hydrophobic compounds, soluble in alcohol (among others) and only a little soluble in water.

Keywords: Essential Oils,Antimicrobials

1. Introduction

According to the ISO 9235 from the International Organization for Standardization (ISO), the essential oil can be obtained by distillation by any of its variants: hydrodistillation, steam distillation, or dry distillation and by mechanical processes [1]. Some of these distillation methods are widely reported in the literature [2][3][4][5], even some variants such as distillation with cohobation [6] have been reported. Because essential oils are responsible for the aroma of plants, they are widely known for their use in cosmetics and perfumery, but they are also an important resource in other industrial fields such as pharmaceutical, food, among others [7][8][9][10]. Indeed, and according to Turek and Stintzing [7], they are a viable environmental-friendly alternative in these fields due to their proved capacity as nematicidal [11][12], antimicrobial [13][14], insecticidal [15], antifungal [14][16] or, even, herbicidal and insect repellent [17]. Besides this, essential oils show antioxidant activity (that can be used in edible products or active packaging) [18], anticancer properties [19], and properties for pain or inflammation treatment [20].

Chemically, essential oils are complex mixtures of more than 100 components [9][10][21], but they are mainly made up of terpenic compounds [22]. Terpenoids, sometimes called isoprenoids, are a broad family of natural compounds derived from isoprene [23]. About 60% of known natural products are terpenoids [24]. This class of secondary compounds (essential oils) contains different terpenoids such as monoterpenes (C_{10}) [17][25] contain two isoprene units (linear or cyclic [25]) like myrcene, menthol, limonene, or linalool (see Figure 1). Other important components of essential oils are the sesquiterpenes which consist of three isoprene units (C_{15}) [17][25]. Figure 1 shows some different sesquiterpenes such as patchoulol or nootkatone (see Figure 1). According to the information reported by Martinez (2003) [10], monoterpenoids are common in the Primulales, Ranunculales, and Violales orders (being scarcer in other different orders such as Asterales, Cornales, Lamiales, and Rutales) and sesquiterpenoids are mainly abundant in other orders such as Asterales, Cornales, Magnoliales, and Rutales [10]. Essential oils can also contain diterpenes (as by-product) [25] which are composed of four isoprene units -as retinal or phytol-. Finally, essential oils contain other compounds such as aromatic phenols, ethers, esters, alcohols, among others, which will confer the aroma and odor of the plant [17].

Figure 1. Some monoterpenoids and sesquiterpenoids presented in essential oils.

Essential oil components can convert without difficulty into each other by a different process (cyclization, isomerization, oxidation, among other ways) due to their structural relation inside the same chemical group [7].

The chemical composition of essential oils depends on different factors such as plant's physiology, climate characteristics or, even, soil conditions where the plant grows [6]. According to this, within the same plant species, or even in their different organs, the chemical composition may vary[6]. The chemical composition can also be influenced by plant health or harvest time [7].

According to Montoya Cadavid [26], around 60 and 80 families produce essential oils, the largest number grows in tropical climates, although they are also found in other climates, with the spermatophytes as the main plants that produce essential oils. Essential oils are found in the different organs of the plant [10][26]: roots (e.g., turmeric, saffron, ginger, and sandalwood), flowers (e.g., thyme, lavender, arnica, and chamomile), fruits (e.g., laurel, coriander, parsley, or pepper), and in other parts such as seeds or leaves, among others.

2. Advantages and Drawbacks of Essential Oils Based Biopesticide for Crop Protection Control

Many studies have shown that different constituents of essential oils can present antibacterial and antifungal properties so that there are real possibilities to used essential oils for plants and crop protection. These kinds of products, made based on essential oils, could be considered as biopesticides. However, different authors suggest that the term "biopesticide" should be reserved only for living organisms (biological agents) [27][28]. This definition is too restrictive and would not include different products derived from the metabolism of the biological organisms [27][28] (plants in our case). Thus, in the current crop protection situation, a wide definition of biopesticides could encompass all compounds of biological origin and seem more suitable [27].

Essential oils-based biopesticides present some advantages for crop protection. Numerous essential oils, that have a large number of plants, cover a wide spectrum of activities against pest insects and pathogenic fungi [29]. These compounds show highly useful against a broad range of agricultural pests and diseases [30]. They present a low persistence in the medium due to its high volatility [29] so that they produce little or no toxic residue and as a result, they do not pollute the soil or groundwater. Besides this, the most essential oils are reasonably nontoxic to mammals and aquatic life and they can be classified as low-risk pesticides [29], in other words, essential oils could present low toxicity against non-target organisms [30]. Another advantage of this group of compounds is that some essentials oils are available in large measure, due to this, the commercialization of pesticides based on essential oils is possible [29], besides, for its application, the same spray equipment can be often used [31] which means that the end-user should not acquire any new equipment for the use of these biopesticides.

On the other hand, and due to that essential oils are a complex mixture of compounds, the possible development of resistance by the pest is slow [29] or less probable [30]. Finally, the use of biopesticides frequently presents good compatibility with conventional chemical pesticides and with biological pest control agents [31].

Although essential oils (and biopesticides in general) have shown many advantages over the use of traditional/conventional pesticides, they present several disadvantages. At the commercial level, not many kinds of this product have arisen in the market, probably due to the high cost of necessary evaluations (toxicology and environmental) [29] because the authorization processes of these biopesticides (botanical pesticides) are complex [30]. Furthermore, according to Isman [32], it would be necessary to have sufficient availability, uniformity, and purification technology protection and a homologation following a regulatory framework. Besides, essential oils are a complex mixture of compounds (beneficial effect to slow down resistance [29][30]), nevertheless, the characterization and specificity detection of each compound that constitutes the essential oil is inaccessible for their use in agricultural farms [29].

On the other hand, some biopesticides can show low persistence (something positive) but they can also be considered as a drawback after application because essential oils can suffer gradual biodegradation of their active substances after application [30]. Related to this, essential oil-based pesticides present less effective when they are compared with other synthetic/conventional chemical pesticides [29][31]. Finally, these kinds of pesticides generally require higher application rates, which together with the need to apply the product frequently, makes their use expensive and time-consuming [29].

To finish, Pavela and Benelli [30] reported that there are numerous studies centered on the biological activity of essential oils on target organisms, nevertheless, it would be necessary to further research toxicological studies and the possible effects of their use on non-target ones. Furthermore, according to the same authors [30], the mechanisms of action and other properties of interest have not yet been clarified. Despite this, the authors report that based on the existing toxicological studies, it can be concluded that the most essential oils can be considered safe (for human and the environment) in the concentrations or doses commonly used, and based on this, the legislation could be simplified and establish a greater partnership between research and the manufacturers of botanical pesticides [30].

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