PESQUISA NA CADEIA DE SUPRIMENTOS DE PLANTAS AROMÁTICAS

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(ORGANIZADOR)

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APRESENTAÇÃO

O livro “**Pesquisa na Cadeia de Suprimentos de Plantas Aromáticas**” de publicação da Atena Editora apresenta em seu primeiro volume 5 capítulos associados a inovações tecnológicas com uso de plantas aromáticas e medicinais.

As plantas medicinais e aromáticas são utilizadas na medicina popular desde os tempos passos por comunidades indígenas, rurais e urbanas visando à prevenção de enfermidades por meio do uso de chás, compressas, banhos, xaropes, entre outras formas de uso. Nos últimos anos, a busca por uma vida de qualidade tem reforçado o resgate da importância e uso das plantas medicinais, sejam elas exóticas e/ou nativas das diferentes fitofisionomias.

Atualmente foi liberada pelo Ministério da Saúde uma Relação de Plantas Medicinais de interesse ao Sistema Único de Saúde (RENISUS), constituída de 71 espécies, contribuindo para implantação de hortos medicinais em postos de saúde, escolas públicas e privadas e instituições de ensino superior em diversos estados do Brasil.

Além disso, as plantas medicinais e aromáticas apresentam potencial tecnológico, pois podem ser inseridas na cadeia industrial e controle fitossanitário, especialmente pela ação que o óleo essencial que muitas espécies detêm. Neste volume, serão abordados trabalhos referentes à alelopatia, controle de plantas espontâneas, uso de óleo essencial em leveduras de panificação, métodos de extração de óleo essencial e sua composição química.

Os agradecimentos do Organizador e da Atena Editora aos estimados autores que empenharam-se em desenvolver os trabalhos de qualidade e consistência, visando potencializar o avanço de uso de fitoterápicos e em bioprocessos.

Espera-se com esse livro incentivar alunos de graduação e pós-graduação, bem como pesquisadores de instituições de ensino, pesquisa e extensão ao desenvolvimento estudos de associados ao cultivo, caracterização fitoquímica e comprovação cientifica das propriedades das plantas medicinais, incentivando o resgate cultural e fortalecimento da cadeia de plantas medicinais e aromáticas, almejando contribuir na qualidade de vida da sociedade e desenvolvimento sustentável.

Cleberton Correia Santos

SUMÁRIO

CAPÍTULO 1

POTENTIAL USE OF ESSENTIAL OILS IN BAKER´S YEAST

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RESUMO: Este capítulo fornece um panorama geral sobre as aplicações dos óleos essenciais sob uma perspectiva global. Esta visão mais abrangente tem como objetivo cobrir a extensa gama de aplicações industriais dos óleos essenciais, salientando sua importância em diversas áreas. Além disso, avanços e novos estudos são mostrados para estimular o pensamento criativo e encorajar o leitor a obter a informação e descobrir tendências que vão além das aplicações tradicionais.

Na primeira parte, definições, o contexto histórico e características dos óleos essenciais derivados de plantas são brevemente descritos. Os principais compostos com propriedades biológicas significativas e efeitos antimicrobianos são citados de forma resumida. As partes subsequentes retratam o uso dos óleos essenciais no contexto industrial. Por esta razão estudos focados no tanto na aplicação tradicional como nas mais recentes perspectivas são apresentados. Por fim, resultados oriundos de experimentos usando óleos essenciais e leveduras de panificação são demonstrados e discutidos. Estes ensaios tiveram o objetivo de avaliar o efeito dos óleos essenciais em sistemas que utilizam linhagens de *Saccharomyces cerevisiae*, comumente utilizada em diversos ramos industriais. Este capítulo aborda as potenciais aplicações da pesquisa em óleos essenciais (OE) para vários segmentos industriais compreendendo desde o uso mais básico e convencional até as aplicações de vanguarda em processos que adotam leveduras de panificação como plataforma para processos fermentativos.

USO POTENCIAL DE ÓLEOS ESSENCIAS EM LEVEDURAS DE PANIFICAÇÃO

ABSTRACT: This chapter provides an overview of applications of essential oils (EOs) using a global perspective. This broad view aims to cover the extensive industrial applications of EOs, highlighting their importance in several fields. Recent advancements are highlighted to illustrate "out-of-box-thinking" and to encourage readers to acquire information regarding trends beyond traditional applications of EOs. In the first section, definitions, historical contexts and characteristics of plant-derived EOs are briefly outlined. The compounds with significant biological properties and antimicrobial effects are summarized. Subsequent sections describe the use of EOs in the industrial context. We present studies focused on both traditional applications and the latest perspectives Finally, results from experiments using essential oils and baker´s yeast strains are discussed. These studies aimed to evaluate the effects of EOs in systems that use *Saccharomyces cerevisiae* strains, commonly used in numerous industries. This chapter addresses the potential applications of EOs in industries ranging the most basic and conventional uses to the cutting edge applications in processes that adopt baker´s yeast as the platform for fermentation processes.
KEYWORDS: *Saccharomyces cerevisiae;* Baker´s yeast; Essential oils; Industrial applications

1 I ESSENTIAL OILS – HISTORY AND BRIEF OVERVIEW

Human use of plants dates back to antiquity. From the Neolithic Age, when humans began cultivating plants and extracting oils using stone tools, up to today, plants have played important roles as natural resources to satisfy needs related to health as well as to food (MAZOYER; ROUDART; 2010; GURIB-FAKIM, 2006).

Several ancient historical records show that combinations of ointments and oils produced from various plant species were widely used worldwide (HALBERSTEIN, 2005; SENDRA, 2016). Evidences of medicinal and aromatic plants date back to 5000 years ago in India, China and Egypt as well as in Greece and Central Asia over almost 2500 years (ANG-LEE et al. 2001; JAMSHIDI-KIA. et al. 2018).

Aromatic and medicinal plants were usually used as extracts or ointments. In fact, these plants are rich in specialized secondary metabolites, especially essential oils.

Essential oils are a mixture of several compounds, mainly terpenes, alcohols, acids, esters, epoxides, aldehydes, ketones, amines and sulfides. These phytochemicals are produced by plants in response to stress; indeed, plants possess a wide range of tools to combat pathogenic infections (THEIS; LERDAU, 2003).

These compounds are also known as *volatile* or *ethereal oils*. The name '*essential oil*' is thought to have originated from the term coined in the 16th century by the Swiss medical reformer Paracelsus von Hohenheim; he referred to the effective component of a drug as *Quinta essentia* (GUENTHER, 1948).

Guenther (1948) described essential oils as aromatic oily liquids obtained from various parts of plants, including flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots. Despite the fact essential oils are not strictly-speaking oils, they are frequently poorly soluble in water, a characteristic of oils in general (DEANS; RITCHIE 1987; HAMMER et al.1999; BURT, 2004; SÁNCHEZ et al., 2010).

2 I APPLICATIONS OF ESSENTIAL OILS

Because essential oils contain volatile components with antimicrobial activities, they have been used for centuries for medicinal as well as for cosmetic purposes. Furthermore, they often have a specific odor and sometimes a distinctive and pleasant taste, the main reason why they are used commercially in significant amounts in the flavor and fragrance markets (BURT, 2004).

According to countless authors, including CONNER (1993), plant-derived essential oils have long served as flavoring agents in foods and beverages. Because of their versatility, including their antimicrobial properties, essential oils may potentially replace synthetic additives as natural agents for food preservation.

In recent decades, several studies have been conducted with natural products focusing on antimicrobial properties; this research has been stimulated by increasing signs of negative effects caused by consumption of synthetic preservatives.

More recently, the popularity of natural products has been increasing and has impacted various essential oil applications, as consumer perception towards food preservatives has changed simultaneous with increased interest in clean-label food products (DENGATE et al., 2002; PRIFTIS et al., 2007).

Because of the wide range of essential oils and their effects, they have received attention not only as from the flavoring and perfume industries in recent years, but also from other industrial segments. Consequently, many researchers have studied plant-derived essential oils and their applications.

Essential oils and their components have been extensively studied, not only for traditional use in perfumery, cosmetic and flavor industries, but also for alternative functions, including antibacterial (DEANS; RITCHIE,1987; OUSSALAH et al., 2007; FREIRES et al., 2015; SANTOS et al.,2017), anti-parasitic (GEORGE et al., 2009; COSTA et al., 2009), insecticidal (ESSAM, 2001; KIM et al., 2003), antifungal (FITZGERALD et al., 2003, KALEMBA;KLUNICKA, 2003;TSERENNADMID et al., 2011; FREIRES et al., 2015), and antioxidant, as well as growth and health promoters (BRENES; ROURA, 2010).

3 I NEWEST POTENTIAL APPLICATIONS OF ESSENTIAL OILS

In the last two decades, as a consequence of the advances in chromatography and chemical analysis, several studies have been undertaken to characterize the composition of essential oils. These studies have involved medicinal and aromatic plants from various parts of the world, including endemic plants that may provide a wide range of components in varying amounts and proportions (SARTORATTO et al.,2004; VIUDA-MARTOS et al. 2011; BALLESTER-COSTA et al., 2013; SHAROPOVet al., 2015; MARÍN et al., 2016).

According to Raut and Karuppayil (2014), several innovative applications using essential oils go beyond traditional uses. These authors mention studies of essential oils applied as anti-protozoans, anti-diabetics, anti-inflammatories, antioxidants, antivirals, and anti-mutagenics.

Given the fact that more than one million compounds have been discovered in natural sources, and that among them 50%–60% are produced by plants, plant-derived essential oils should be emphasized. Several compounds promise high potential to be explored by numerous industrial segments (BERDY, 2005).

Among the various segments in which essential oils can be applied, the food, animal husbandry and agriculture industries are worth highlighting.

Unquestionably, in the context of food industry, the main application of essential oils has been related to their use as flavorings as well as preservatives, because there has been a growing demand for their antifungal, antibacterial and antioxidant properties.

Essential oils should also be considered for food preservation because of several difficult challenges in terms of contamination and spoilage. One of these is related to substantial concern over multidrug-resistant microorganisms on the part of regulatory agencies. Furthermore consumer food preferences are moving away from synthetic additives and preservatives and there is an increasing demand for minimally processed foods and natural preservatives.

In short, essential oils are highly valued by the food industry because they are well-suited for use in organic foods, permitting the use of clean labels on foods.

Nevertheless, the use of essential oils present limitations, because in some cases they cause sensory changes derived from their strong odors, flavors and colors, all of which may change the original characteristics of foods (KUORWEL et al. 2011).

Research on essential oils' biological activities has become increasingly crucial for the pursuit of natural and safe alternative preservatives and health promoters. In this regard, essential oils are used as feed additives for ruminants to alter ruminal metabolism so as to reduce methane and ammonia emissions (COBELLIS et al., 2016).

Another important segment of application of essential oils is related to their use as replacements for antibiotic growth promoters both in animal husbandry and some agricultural processes. In spite of their mode of action in animals, their role remains superficially understood and requires deeper investigation (PEREIRA et al., 2010; NEGI, 2012; COBELLIS et al., 2016; BENTO et al., 2013).

Despite the substantial number of studies of essential oils as potential antimicrobials and as food preservatives, very few reports show their application in processes that use *Saccharomyces cerevisiae*.

Saccharomyces cerevisiae is used to produce bread and other bakery products. It is also widely employed in several industrial segments as a platform for fermentation processes.

4 I BAKER´S YEAST - *Saccharomyces cerevisiae*

In the same way that plant-derived essential oils have shown remarkable applications since antiquity, yeasts have been widely reported in historical documents from several cultures throughout history (FLEET, 2006). Among yeasts, *Saccharomyces cerevisiae* has been one of the most important domesticated microorganisms.

This microorganism has been extensively used in several fermentation processes since antiquity because of its versatility and capacity to act on various substrates. Interestingly fermentation processes employing *S. cerevisiae* remain common and represent a significant component of modern industrial processes.

In the food industry, *S. cerevisiae* is a double-edge sword. On the one hand, it often appears as a contaminant (STRATFORD, 2006; TYAGI et al., 2014). By contrast, a number of strains of this microorganism are employed as baker´s yeasts to produce bread and other bakery products. Furthermore, several strains are used in industrial fermentation processes to produce beer, wine, and bioethanol.

As mentioned above, there is a trend toward green consumerism, not only in the food industry. Essential oils have also recently emerged as possible sources of safe and natural antimicrobial agents.

Long-term selection and domestication of *Saccharomyces cerevisiae* has led to selection and use of various strains with characteristics appropriate for distinct fermentation processes. Consequently, the effects of plant-derived essential oils on yeast strains used in various fermentation processes are fundamentally important for understanding its action and possible future applications.

The next section summarize some findings from our studies using essential oils in baker´s yeast strains.

5 I EFFECT OF ESSENTIAL OILS IN BAKER´S YEAST *Saccharomyces cerevisiae* STRAINS

Our group studied the effect of 25 plant-derived essential oils on strains of *S. cerevisiae* from the bakery industry (Figure 1). We cataloged growth-inhibition profiles following exposure to essential oils at varying concentrations. All strains were isolated from different baker´s yeasts: stronger baker´s yeast, active dry baker´s yeast, and sweet dough baker´s yeast. All were distinguished by karyotyping using pulsed field gel electrophoresis (PFGE).

The essential oils used were extracted from plants belonging to the Medicinal and Aromatic Plant Collection (CPMA) of Chemical, Biological and Agricultural Multidisciplinary Research Center (CPQBA) at University of Campinas (UNICAMP) in Brazil.

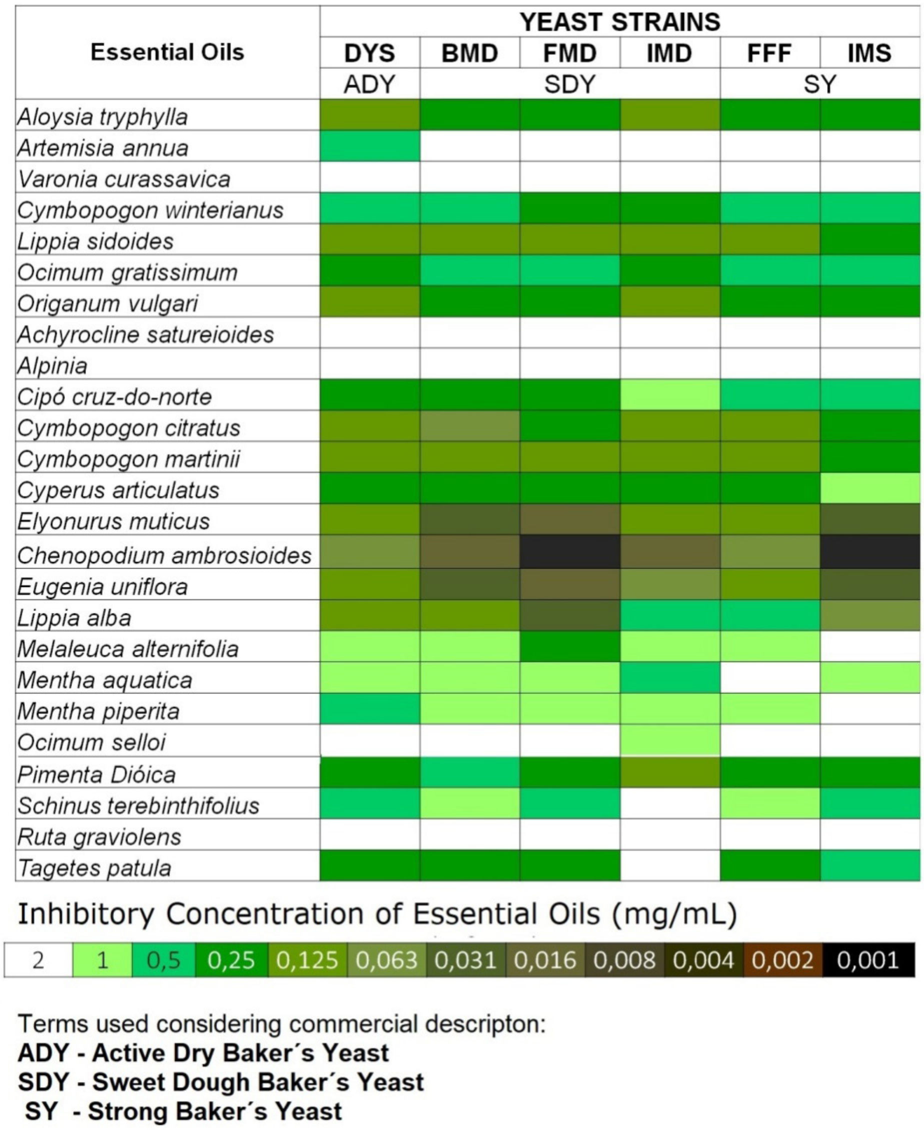

FIGURE 1 Effect of essential oils (EOs) on baker´s yeast strains growth

The 25 plant-derived essential oils (Figure 1) were analyzed using gas chromatography – mass spectral analysis (GC-MS) (ADAMS, 2007). Oil components were identified by comparison of mass spectra and retention indices with spectral library and literature. A different activity profile of essential oils in the face of baker´s yeast strains was found. Among them, two groups can be highlighted: (I) Essential oils with severe effects on baker´s yeast and (II) Essential oils that had no effect on baker´s yeast. In the first group, two essential oils should be mentioned:*Elionurus muticus* and *Chenopodium ambrosioides.* In the second group, three essential oils deserve to be highlighted: *Alpinia; Achyrocline satureioides*; and *Varronia curassavica.* We will discuss *A. satureioides*; *E. muticus* and *V. curassavica* in more detail.

5.1 Elionurus muticus

The genus *Elionurus* Humb.et Bompl ex. Willd (Gramineae) is common in subtropical regions of South America, Africa and Australia. In Brazil *E. muticus* is native to the Pantanal biome and is popularly called “Capim-Carona.” This plant has been studied for its negative effects in animal husbandry (SANTOS et al., 2005).

Similar to results shown in Figure 1, in which this essential oil presented one of the most severe effects on all S*accharomyces cerevisiae* strains isolated from baker´s yeast, studies have demonstrated strong antimicrobial inhibitory effects of this oil in yeasts of the *Candida* spp. (SABINI et al., 2006).

Although *E. muticus* essential oil has been mentioned as a repellent (STEFANAZZI, et al., 2011) and antimicrobial for *Candida* species, there are no studies of its effect on *S. cerevisiae.* The main chemical compound found in *E. muticus* essential oil was citral, a mixture of two geometric isomers known as geranial and neral that represent 82% of their composition.

Given the fact that *S. cerevisiae* are model of eukaryotic cells, the severe effect of this oil should be considered when used for human applications due its possible toxicity and need to be deeply studied.

5.2 *Achyrocline satureioides*

Achyrocline satureioides (D.C.) Lam. (Asteraceae), known as "marcela hembra" (Uruguay and Argentina), "marcela do campo" or "macela" (in Brazil) is a medicinal plant native to southeastern South America and is distributed as well in Europe and Africa. This aromatic plant has been traditionally used as an infusion of the dried flowers and flowered stems by local populations for medicinal purposes (LORENZO et al., 2000).

In our study, the essential oil extracted from A*. satureioides* was found to be harmless for all baker´s yeast strains evaluated. Several studies conducting chemical characterization of *A. satureioides* essential oils showed that α-pinene and caryophyllene were major components, consistent with our results (45%of α-pinene; 25% of caryophyllene and 13% of α-humulene). The data showed that there was no inhibitory action on any *S. cerevisiae* strains when the *A. satureioides* essential oil was present at all concentrations tested.

Other studies, including research conducted by Mota et al. (2011) demonstrated the antibacterial effect of this oil. For all these reasons, there is a potential of this essential oil to be studied in depth for fermentation systems that use baker´s yeast.

5.3 *Varronia curassavica* (sin = *Cordia verbenaceae* DC.)

Varronia curassavica Jacq. (sin = Cordia verbenaceae DC.), Boraginaceae, popularly known as "erva-baleeira", "catinga-de-barão", "maria-preta" and "maria-milagrosa" occurs naturally from Central to South America. In Brazil, it occurs in the Atlantic Forest biome. This traditional medicinal plant has been used to treat several inflammatory disorders, including ulcers and arthritis (FEIJÓ et al., 2014).

As with the essential oil of *A. satureioides*, the *V. curassavica* essential oil was also shown to be harmless for all baker´s yeast strains evaluated, at all concentrations tested. Likewise, chemical characterization studies of *V. curassavica* essential oil showed that α-pinene and caryophyllene were the major components (CARVALHO et al., 2004). Our study supports these results (33%of α-pinene; 33% of caryophyllene and 7,5% of α-humulene) and demonstrates the absence of inhibitory effect of *V. curassavica* essential oil on all baker´s yeast strains. As with *A. satureioides,* there are many studies using *V. curassavica* essential oil, demonstrating an antibacterial effect (RODRIGUES et al., 2012); for this reason, this oil presents potential in systems that use baker´s yeast.

CONCLUSION

In this chapter, we provided an overview of applications for essential oils.

Plant-derived essential oils offer a wide range of useful properties. A series of ongoing investigations are demonstrating various advantages with application of essential oils. Several authors have highlighted the reduction of genotoxicity (even after prolonged use), lower toxicity, and the ability to act on several targets as the main reasons for their beneficial characteristics. Furthermore, use in 'eco-friendly' products, associated with low costs of production, increases profitability of their use.

We highlighted traditional and new applications, as well as potential applications in systems that employ baker´s yeast in fermentation processes.

Generally, the concept of essential oils as antimicrobials can be considered a traditional approach. Nevertheless, the use of essential oils in baker´s yeast strains should be considered an innovative application, because there are no studies using both of them. Furthermore, *S. cerevisiae* strains strongly impact food and beverage production.

The effects of essential oils or their several components in fermentation processes need further exploration because a range of essential oils have been accepted by the European Commission. The United States Food and Drug Administration (FDA) has also classified these substances as generally recognized as safe (GRAS). Studies using essential oils in *Saccharomyces cerevisiae* strains may be applied as screening techniques for antimicrobials to be used in fermentation processes, because there is great potential for new molecules and phytochemical discoveries based on essential oils that are extracted and characterized from traditional and medicinal plants worldwide.

Considering our present knowledge and future perspectives, the use of essential oils on yeast strains is only beginning, and there is a long journey ahead.

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