Essential Oils as Preservatives in Cosmetics: An Integrative Review

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ABSTRACT

Cosmetics are more natural and sustainable due to pressure from the current society, which requires modification in traditional components, usually synthetic Preservatives, which aim to extend products due to their ability to inhibit the growth and proliferation of microorganisms, are at the forefront of this change. The present study is characterized as an integrative review carried out about the use of essential oils (EO) as a cosmetic preservative, evaluating its effectiveness to replace or complement the current preservative system. The research’s guiding question was: EOs are effective as cosmetic preservatives and substitute equivalents for synthetic ones? Twenty-eight articles were selected in the consulted databases (Google Scholar, PubMed, and Scielo). EOs are promising natural preservatives either alone or combined with other EOs and with synthetic preservatives and additives. The results in vitro and cosmetic formulations demonstrated antimicrobial action in a broad spectrum of microorganisms. However, there is no standardization of the methods used to assess the antimicrobial efficacy and few studies with continuity, being necessary to carry out more studies concerning the preservative activity in ready-made cosmetic formulations and in vivo studies with humans using the final product for comparison and, in the future, replacement of synthetic preservatives by the OE.

KEYWORDS: Preservative; Essential oil; Cosmetics; Microbiological efficacy

INTRODUCTION

The cosmetics industry underwent a reformulation, where it began a greener production using resources from the biodiversity of the generating country [1]. This production is due to the population has re-signified the concept of cosmetics, with greater concern about environmental preservation and sustainability, as well as individual well-being and health [2]. Thus, cosmetics are becoming more natural and sustainable and, with this, changes in formulations are being made by components that act in the same way as traditional (usually synthetic).

Any product containing water and organic/inorganic compounds, such as cosmetics, needs an intelligent strategy against microbial contamination [3]. Based on the above, one of the compounds currently discussed is the preservative, which is responsible for the safety of the product to the consumer, so its choice must consider the susceptibility to contamination, physical characteristics-chemical, and possible incompatibilities to avoid changes [4].

Parabens, a class of synthetic preservatives, are the most widely used. Since 1920, its use in the pharmaceutical industry was initiated by its broad spectrum of action, eliminating both fungi and Gram+ bacteria [5]. Currently, methylparaben and ethyl paraben are the most used types in cosmetics because they have good compatibility with formulations, low toxicity, and allergenicity, and low cost; moreover, they are odorless, colorless to white, and active in a wide range of pH and temperature, being used on the skin, hair, lips, nails, and mucous membranes being their oral and topical use may be uninterrupted [6]. However, due to consumer demands and some studies demonstrating certain risks to human health [7], synthetic chemical preservatives are being set aside by a more natural option. There is a higher demand for natural compounds that can act as a preservative in cosmetics and foods [8]. Because of this, companies are looking for alternative ones with a broad spectrum against pathogens and with a safer feature for consumers [3]. Generally, natural ingredients can also be used in...
cosmetics as functional additives, once their antimicrobial activities are an alternative way to solve the problem of microbial purity of cosmetics [9]. The class of essential oils (EOs) is one of the many natural alternatives for preserving cosmetic products [10]. Thus, this integrative review aimed to evaluate the effectiveness of EOs to replace or complement the current preservative system. In addition, the study reports the main EOs used as preservatives, describing their mechanisms of action and the efficacy tests performed.

METHODS

This is an integrative review where the guiding question of the research was: Are EOs effective as cosmetic preservatives and substitute equivalents for synthetics? Thus, this study carried out a review in the scientific databases: Google Scholar, Pubmed and Scielo, being conducted from March to August 2020. The following keywords were used in the search for the articles, with different combinations in Portuguese and English: preservative, cosmetic, essential oil, paraben.

The inclusion criteria defined for the selection of the articles were: scientific articles published with online access, in full text, in Portuguese and English, related to the theme preservative action (antimicrobial, antibacterial, and/or antifungal) in the last twenty years (2000 to 2020). The following exclusion criteria were considered: publications classified as a thesis, letter, dissertations, monographs, manuals, and protocols; and articles that did not address the research question. Figure 1 shows the steps followed in the article selection process.

RESULTS

The twenty-eight selected articles were segregated and grouped into three categories created according to the subjects addressed in each study, namely: A) scientific articles related to descriptive studies of EOs and its antimicrobial action; B) experimental studies of EOs in cosmetic formulations; D) experimental studies of EOs compared or combined with parabens (Table 1).

| Authors          | Year | Title                                                                 |
|------------------|------|----------------------------------------------------------------------|
| Juliano et al.   | 2000 | Composition and in vitro Antimicrobial Activity of the Essential Oil of Thymus herba-barona Loisel Growing Wild in Sardinia |
| Cox et al.       | 2000 | The mode of antimicrobial action of the essential oil of Melaleuca alternifolia (tea tree oil) |
| Cox et al.       | 2001 | Interactions between components of the essential oil of Melaleuca alternifolia |
| Maccioni et al.  | 2002 | Preservative systems containing essential oils in cosmetic products |
| Nostro et al.    | 2002 | Preservative properties of Calamintha officinalis essential oil with and without EDTA |
| Muyima et al.    | 2002 | The potential application of some novel essential oils as natural cosmetic preservatives in an aqueous cream formulation |
| Nostro et al.    | 2004 | Efficiency of Calamintha officinalis essential oil as preservative in two topical product types |
| Pinto et al.     | 2006 | Antifungal activity of the essential oil of Thymus pulegioides on Candida, Aspergillus and dermatophyte species |
| Oussalah et al.  | 2006 | Mechanism of Action of Spanish Oregano, Chinese Cinnamon, and Savory Essential Oils against Cell Membranes and Walls of Escherichia coli O157:H7 and Listeria monocytogenes |
| Gachkar et al.   | 2007 | Chemical and biological characteristics of Cuminum cyminum and Rosmarinus officinalis essential oils |
| Kunicka-Styczynska et al. | 2009 | Antimicrobial activity of lavender, tea tree and lemon oils in cosmetic preservative systems |
De Martino et al. [22] 2009 Chemical Composition and Antimicrobial Activity of the Essential Oils from Three Chemotypes of *Origanum vulgare* L. ssp. hirtum (Link) Ietswaart Growing Wild in Campania (Southern Italy)

Patrone et al. [37] 2009 In vitro synergistic activities of essential oils and surfactantes in combination with cosmetic preservatives against

Kunicka-Styczyńska et al. [19] 2011 Lavender, tea tree and lemon oils as antimicrobials in washing liquids and soft body balms

Adaszyńska et al. [41] 2011 The possibilities or using essential oils as inactive ingredients or preservatives in cosmetic products

Bassolé et al. [39] 2012 Essential Oils in Combination and Their Antimicrobial Properties

Tian et al. [47] 2012 The Mechanism of Antifungal Action of Essential Oil from Dill (*Anethum graveolens* L) on Aspergillus flavus

Wang et al. [23] 2012 Antibacterial Activity and Anticancer Activity of *Rosmarinus officinalis* L. Essential Oil Compared to That of Its Main Components

Vorgancioğlu et al. [49] 2013 Production of cosmetic purpose collagen containing antimicrobial emulsion with certain essential oils

Herman et al. [9] 2013 Essential Oils and Herbal Extracts as Microbial Agents in Cosmetic Emulsion

Azizkha et al. [21] 2013 Effects of Zataria multiflora Boiss. essential oil on growth and gene expression of enterotoxins A, C and E in *Staphylococcus aureus* ATCC 29213

Dreger et al. [35] 2013 Application of essential oils as natural cosmetic preservatives.

Herman [20] 2014 Comparison of antimicrobial activity of essential oils, plant extracts and methylparaben in cosmetic emulsions: 2 months study

Chouhan et al. [31] 2017 Antimicrobial Activity of Some Essential Oils-Present Status and Future Perspectives

Cutillas et al. [25] 2017 Thyme essential oils from Spain: Aromatic profile ascertained by GCEMS, and their antioxidant, antilipooxygenase and antimicrobial activities

Hernandes et al. [30] 2017 Lippia origanoides essential oil: an efficient and safe alternative to preserve food, cosmetic and pharmaceutical products

Vieira-Brock, et al. [48] 2017 Comparison of antimicrobial activities of natural essential oils and synthetic fragrances against selected environmental pathogens

Matos Cruz [8] 2018 Atividade antimicrobiana do óleo de Melaleuca alternifolia comparada a conservantes químicos usados em bases cosméticas

### DISCUSSION

**Antimicrobial action of EOs**

The first study addressing the antimicrobial activity of EOs probably came from Kabara [11], using plant extracts and EOs as preservative and noting the possibility of replacing synthetic preservatives in cosmetic products. Therefore, this strategy is historically recent, coinciding with the environmental concern and toxicological potential of what we consume in the world [12]. However, approximately in the last 20 years, studies have been stimulated to prove the efficacy of EOs and their active components, mainly by the strong discussion of microbial resistance [13,14] and possible adverse reactions in human health [7,15]. This is confirmed in the present results, because there is a growth of studies from 2009 and the years with the highest number of studies were 2013 and 2017.

According to Pereira et al. [16] and Papageorgiou et al. [17], the main EOs used as preservatives are *R. officinalis, Lavandula officinalis, M. alternifolia, T. vulgaris* and *S. officinalis*. In the current study, it was possible to see that *M. alternifolia* was the most studied EO among the selected articles, followed by *L. officinalis*. Most oils had only one study to be analyzed. Most of the articles included analyzed the antimicrobial action of EOs in vitro (13 of 28). *E. globulus* and *M. piperita* were the EOs with lower action and lower effectiveness compared to the others, having little action against *Staphylococcus aureus* and *Pseudomonas aeruginosa*. *S. officinalis* was the third with the lowest results, showing little action against *S. aureus* and *Escherichia coli* and little or no action against *Candida albicans*. The others had good results, presenting effective action in at least one microorganism. It can be showed a highlight to *M. alternifolia* for having action against all the main microorganisms studied and being effective against *S. aureus, E. coli, C. albicans, and Aspergillus Niger, P. aeruginosa*. It was the most resistant microorganism, but it was observed that even against parabens of this microorganism is little affected, being even less effective than *L. officinalis, M. alternifolia* and *C. zeylanicum* at 2.5%, according to a study by Herman et al. [9].

The main mechanisms of antimicrobial action of the EOs observed in the articles were rupture of the external membrane or cellular cytoplasmic leakage of intracellular constituents as ATPase, and inactivation of the mitochondrial activity of microorganisms [8,18-20]. The ratio of antimicrobial activity can be defined by the active compounds of EOs. The most active EOs had groups of aldehydes, phenols, or terpenes in high concentrations, components such as carvacrol, thymol, terpinen-4-ol, linalool, α-terpineol, and 1,8-cineol found in *Z. multiflora* [21], *O. vulgare* [22], *M. alternifolia* [18], and *R. officinalis* [23].

However, it is known that thymol, linalool, and carvacrol have broad-spectrum antimicrobial activity [24,25]. Cox et al. [18] compared *M. alternifolia and its main active compound, terpinen-4-ol*, and they observed higher antimicrobial action of terpinen-4-ol. In addition, this compound allowed the permeation of other microbical components in the cellular cytoplasm. However, it is not only observed in the compounds individually, because in EOs several constituents interact and synergize.

**Evaluation of EOs in cosmetic formulations**

The study in cell cultures is an initial analysis and cannot confirm with certainty whether these results will be equal in cosmetic formulations [9]. Because a product has a diverse chemical composition, it can positively or negatively influence the preservative activity of EOs since its action will be the result of synergistic and antagonistic activity of the active components.
Evaluation of EOs Combined with other EOs

The use of EOs as cosmetic preservatives was further studied by the selected articles within a preservative system. This strategy aims to combine more than one ingredient with preservative capacity and/or with potentiating action of the antimicrobial activity of others to make the conservation of the cosmetic product more effective and safer. Preservatives used in cosmetics should have antiseptic power in a wide range of temperature and pH, being effective against various types of microorganisms and not present toxicity and side effects [34]. For EOs to replace synthetic preservatives they must comply with these points. Altogether, being natural does not exclude its toxicological or allergic potential [35]. Regarding toxicity and side effects, no specific article was found, therefore, studies are needed in this aspect. According to Dreger [35], the toxicity of EOs can be classified as low or medium, the majority being considered safe, however, it has the risk of causing irritation, sensitization, phototoxicity, or allergic reactions [36]. Hernandez et al. [30] analyzed the mutagenic potential and acute toxicity of 0.125% L. origanoids and concluded no mutagenic effects.

A combination of E. globulus and M. piperita increased the action of methylparaben and propylparaben against P. aeruginosa [37]. In the same study, the combination of M. piperita, O. vulgare, and R. officinalis increased diazolidinyl urea activity against P. aeruginosa, C. officinalis only affected and reduced the cell viability of P. aeruginosa when combined with EDTA in ointment in the study by Nostro et al. [38]. The mixture of L. nobilis and E. Globus or E. globulus and S. officinalis or combined with methylparaben were effective against P. aeruginosa in gel formulation [29]. Besides, C. Limon and M. alternifolia were only effective against P. aeruginosa when combined with L. officinalis and/or synthetic preservatives [19].

Evaluation of EOs Combined with Paraben

Only 5 studies comparing EOs with parabens were found [8,9,20,27,37]. In comparison with the paraben mixture Fenonip (Methylparaben, Ethylparaben, Propylparaben, Diethylparaben, 0.5% each), C. officinalis reduced the number of viable microorganisms by 2%. In addition, Matos e Cruz [8] confirmed similar antimicrobial activity among synthetic preservatives, presenting the similarity in the results of M. alternifolia against E. coli compared to the mixture of Methyl and Propylparaben. Herman et al. [9], noting that the EOs studied were more effective against S. aureus, E. coli, and C. albicans than Methylparaben, confirmed that mixing different EOs can effectively inhibit microbial growth across a broad spectrum of activity, it is possible to replace or significantly reduce the number of synthetic preservatives added to cosmetics. Few studies comparing synthetic preservatives with EOs made this discussion promising, but not definitive, and there should be more tests comparing the activity of EOs and traditional preservatives.

Parallel in vitro and in vivo studies have only been seen in one article and cannot be determined whether all EOs are compatible with the chosen preservative system and can ensure the microbiological purity of cosmetics during use and storage. As confirmed by Herman [20], positive results of C. zeylanicum (2.5%) in an in vivo study with 40 volunteers for 2 months. This EO completely inhibited bacterial and fungal growth in a cosmetic emulsion, having a better result than the groups that used methylparaben as a preservative. More in vivo studies are expected to confirm the efficacy of EOs as a preservative in finished products and used in clinical practice.

Evaluation of EOs Combined with Other Preservatives

Regarding efficiency, several studies confirmed the synergistic
potential of EOs to increase activity of other preservatives. Kunicka-Styczynska et al. [19] showed that the synthetic preservative LPG (Glydant Plus Liquid) at 0.1% in combination with L. officinalis and M. alternifolia (each one with 0.5%) significantly increased preservative action. M. alternifolia and C. Citrus 1% combined with 0.2% LPG increased inhibitory activity of preservatives and, with the same EOs at 0.5%, it occurred inhibition of all microorganisms tested after 2 days and increased fungistatic activity of the synthetic preservative. In 2011, the same authors observed a synergistic effect between M. alternifolia, L. officinalis, and C. Limon at 1%. Synergistic action between C. officinalis and EDTA against Gram-negative bacteria was seen [27].

Regarding safety, Kunicka-Styczynska et al. [20], Patrone et al. [37], and Herman et al. [9] cite that the used concentration of synthetic preservatives can be significantly reduced when combined with EOs. This combination allowed to decrease ingredients with allergenic potential in the cosmetic product [35], as seen in the study by Kunicka-Styczynska et al. [19]. With this, we can see that the combination of EOs with synthetic preservatives, additives, or other EOs increases antimicrobial activity to the point of affecting microorganisms normally resistant to traditional preservatives.

Despite the many positive and promising results of the use of EOs as effective alternative preservatives, many studies have not achieved progress, not allowing greater knowledge of the capacity of certain EOs for the cosmetic industry. This is confirmed by seeing that most EOs found in the present review has only one study. The descriptive articles, mainly, highlight problems such as the diversified evaluation methods, not allowing the comparison of the studies in a completely correct way [31,35,39].

Thus, there is no standardized method developed to evaluate the interaction between EOs [40]. Patrone et al. [37] revealed that there is a need to better understand the possible interactions between preservatives and other ingredients with EOs in formulations to select appropriate cosmetic dosages. Muymia et al. [28] also stated the lack of studies evaluating the efficacy of EOs in specific end products. Also, Matos e Cruz [8] expected the standardized antimicrobial susceptibility tests specific to EOs to obtain a greater understanding of yield and production cost to clarify the true bioactivity, and with this, the use of EOs as safe and economically viable alternatives for the cosmetic-pharmaceutical market [41-49].

CONCLUSION

In sum, EOs are promising natural preservatives either isolated or combined with other EOs or synthetic preservatives and additives. Their results in vitro and cosmetic formulations demonstrated antimicrobial action in a broad spectrum of microorganisms. However, there is no standardization of the methods used to evaluate antimicrobial efficacy and few studies with continuity, and it is necessary to perform more experiments concerning preservative activity in ready cosmetic formulations. There is also a lack of comparisons of the action of traditional oils and preservatives and in vivo studies with humans using the final product. EOs can be considered safe to use in a preservative system, reducing the toxicity and concentration of other traditional preservatives, or with other EOs, allowing a broad spectrum of antimicrobial action with natural preservatives.

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