Essential Oil from *Origanum vulgare* Linnaeus: An Alternative against Microorganisms responsible for Bad Perspiration Odour

Suzuki Érika Y¹, Soldati Pedro P¹, Chaves Maria das Graças A. M², Raposo Nádia R. B¹

¹NUPICS, Faculdade de Farmácia, Universidade Federal de Juiz de Fora, Rua José Lourenço Kelmer, s/n, 36036-900 Juiz de Fora-MG, Brasil.

²NUPITE, Faculdade de Odontologia, Universidade Federal de Juiz de Fora, Rua José Lourenço Kelmer, s/n, 36036-900 Juiz de Fora-MG, Brasil.

**ABSTRACT**

**Objective:** The aim of this study was to evaluate the antimicrobial activity of the essential oil from *Origanum vulgare* Linnaeus against the main bacteria responsible for bad perspiration odor (*Corynebacterium xerosis* IAL 105, *Micrococcus luteus* ATCC 7468, *Proteus vulgaris* ATCC 13315 and *Staphylococcus epidermidis* ATCC 12228) and to develop the formulation of a deodorant containing the essential oil as antimicrobial agent. **Method:** The antimicrobial activity was evaluated by means of the turbidimetric method, by using the microdilution assay. The chemical profile of the essential oil was evaluated by high-resolution gas chromatography (HR-GC). **Results:** seventeen constituents were identified, being that γ-terpinene (30.5%) and carvacrol (15.7%) were the major components found. The essential oil exhibited antimicrobial activity against all microorganisms tested and the minimum inhibitory concentration (MIC) values ranged from 0.7 to 2.8 mg/mL. Electron microscopies confirmed the morphological alteration in the structure of the bacteria treated with the essential oil as compared to control. The formulation of the deodorant demonstrated bactericidal activity and it was able to cause damage in the morphological structure of the treated bacteria. **Conclusion:** The essential oil from *O. vulgare* can be used as a potential natural antimicrobial agent to be applied in personal care products.

**Key words:** Deodorants, *Origanum vulgare*, Personal care products, Antimicrobial action.

---

**INTRODUCTION**

Personal care products (PCPs) (e.g. deodorant, toothpaste, soap, shampoo) are constantly used nowadays. Nevertheless, synthetic compounds present in PCPs can affect people’s health and the environment.¹,²

---

*Address for correspondence:*

Dr. Raposo Nádia R. B, Universidade Federal de Juiz de Fora, Faculdade de Farmácia Núcleo de Pesquisa e Inovação em Ciências da Saúde, Campus Universitário – Bairro Martelos, CEP 36036-900 – Juiz de Fora - MG, Brazil. E-mail: nadiafox@gmail.com
Triclosan, a common ingredient used in PCPs, has become the most widely used antibacterial agent in the United States. This biocide is among the most commonly detected PCPs in surface waters and biosolids. Therefore, it has been suggested that exposure to Triclosan in the environment may select tolerant bacterial strains and exhibit increased resistance to antibiotics.\textsuperscript{3,4}

The continuous emergence of bacterial strains resistant to conventional treatments has become a major problem in recent years.\textsuperscript{5} Furthermore, triclosan is sufficiently persistent in the environment, thus it readily bioaccumulates in aquatic organisms, creating a chronic exposure for those organisms.\textsuperscript{3,4,6-8} Due to this fact, there is a growing consumer demand for natural ingredients, which are perceived as being healthier and ecological.\textsuperscript{9} The use of natural products of plant origin demonstrates a low possibility of microbial resistance development because of their complex chemical mixtures.\textsuperscript{10,11} The natural ingredients have been the favorites in the cosmetic and personal care marketing departments, ensuring almost immediate consumer attention, along with the willingness to pay premium prices for such products. According to a Natural Marketing Institute survey, 59\% of women indicate that 100\% natural ingredients are very or somewhat important for them when purchasing PCPs.\textsuperscript{12}

Essential oils and their components are increasingly gaining interest because of their relatively safe status, their wide acceptance by consumers, and their exploitation for potential multi-purpose functional use. They have been used in food preservation, aromatherapy, pharmaceuticals, fragrance industries, alternative medicine and natural therapies.\textsuperscript{13}

Essential oils refer to the subtle, aromatic and volatile liquids isolated from different parts of plants through distillation. Such materials, which are used for their beneficial effect on the skin, are cost-effective and in some instances may enhance the Dermo-cosmetic properties of the final product. Certain essential oils are known to possess other interesting properties, such as antibacterial or antifungal. Such properties allow their usage alone or in combination with chemical preservatives for the preservation of cosmetic products.\textsuperscript{3,4,14,15}

In terms of Ecotoxicology, in contrast to some synthetic products, the constituents of essential oils are biodegradable and most of them have little persistence in the environment.\textsuperscript{16}

Oregano (\textit{Origanum vulgare} Linnaeus) is an aromatic herb belonging to the Lamiaceae family, and distributed in Eurasia, North Africa and North America.\textsuperscript{17} This well-known aromatic herb is considered one of the most widely used spices in the world and is officially accepted in many countries for its medicinal value.\textsuperscript{18} Due to their variety in regards to chemistry and aroma, different \textit{Origanum} species are frequently used as raw material in pharmaceutical and cosmetic industry in order to get spicy fragrances.\textsuperscript{19} Oregano has also been found to exhibit ant thrombin, ant hyperglycemia, ant inflammatory, hepatoprotective as well as antimicrobial effects.\textsuperscript{20-22}

Deodorants belong to the PCPs group and are used to mask and reduce body odor. They usually contain antimicrobials such as triclosan, which decrease the number of bacteria and hence the unpleasant smell of the microbial secretion compounds.\textsuperscript{23} The German market of deodorants rose to € 705 million in 2010 and it was the PCPs with the biggest increase compared to the two previous years. It is estimated that 65.2\% of adult men and 73.3\% of adult women use deodorants at least once a day.\textsuperscript{23,24} Currently, Brazil is the third worldwide market on cosmetics, perfumes and hygienic products and it occupies the first position in the world ranking of deodorants and fragrances.\textsuperscript{25}

In this context, the aim of the present study was to evaluate the antimicrobial activity of the essential oil from \textit{O. vulgare} L. against the main bacteria responsible for bad perspiration odor and to develop a deodorant formulation containing said essential oil as an antimicrobial agent.

**MATERIAL AND METHODS**

**Essential oil**
The essential oil from \textit{Origanum vulgare} leaves (lot 660411) was commercially obtained from Lazlo Aromatologia Ltda.

**Gas chromatography**
In order to qualitatively and quantitatively characterize the main chemical constituents of this essential oil, an aliquot was subjected to analysis by high-resolution gas chromatography (HR-GC) (HP 5890) equipped with flame ionization detector. A BP-1 (SGE) 30 m x 0.25 mm column was used, with a temperature gradient of 60°C/1 min, 3°C/min to 220°C; injector (split of 1/50) at 220°C and detector at 220°C. The carrier gas used was hydrogen (2 mL/min) and the injection volume was of 1 μL. Samples were diluted to 0.5\% in chloroform. Identification of essential oil components was based on the retention times of sample components and a mixture of n-alkanes from C\textsubscript{10}-C\textsubscript{18} and the calculated Kovats Index was compared with the available literature.\textsuperscript{26}
Chemical composition of the essential oil

Seventeen constituents were identified by HR-GC, accounting for 91.6% of all components in the essential oil. Other not-listed components are present in amounts of less than 0.1%. Results showed that γ-terpinene (30.5%)
was the compound in highest percentage in the essential oil, followed by carvacrol (15.7%) and terpinen-4-ol (13.0%) (Figure 1 and Table 1).

Antimicrobial activity

Minimal Inhibitory Concentration

According to the results given in Table 2, the essential oil of *O. vulgare* exhibited the antimicrobial activity against all tested bacteria and demonstrated the bactericidal effect against three of the four tested microorganisms. The MIC values of the essential oil ranged from 0.7 mg/mL to 2.8 mg/mL.

Scanning electron microscopy analysis

SEM observations confirmed the physical damage and considerable morphological alteration to the tested bacteria treated with the oregano oil or reference drugs (chloramphenicol, triclosan and neomycin). Cells treated with essential oil and reference drugs underwent considerable morphological changes when compared to the control group (Figures 2 – 5). Control cells showed a regular surface. Exposure of the antimicrobial agents to the bacteria revealed deformed and destroyed cells with probable depletion of their content. In fact, it seems that such compounds are able to alter the cell membrane of the studied bacteria.

**DISCUSSION**

In the present work, γ-terpinene (30.5%) was present in higher percentage, followed by carvacrol (15.7%), terpinen-4-ol (13.0%), geraniol (7.1%) and cis-ocimene (7.0%). Those compounds account for 73.3% of the total composition of the oil and may be responsible for the biological activity.

The essential oil of *O. vulgare* is widely known to...
Table 2: Minimal Inhibitory Concentrations (MIC) and minimum bactericidal concentration (MBC) of the tested substances.

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Essential oil of <em>O. vulgare</em></th>
<th>Chloramphenicol</th>
<th>Neomycin</th>
<th>Triclosan</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIC&lt;sup&gt;a&lt;/sup&gt;</td>
<td>MBC&lt;sup&gt;a&lt;/sup&gt;</td>
<td>MIC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>MBC&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td><em>S. epidermidis</em></td>
<td>2.8</td>
<td>-</td>
<td>2.5</td>
<td>0.48</td>
</tr>
<tr>
<td>ATCC 12228</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>P. vulgaris</em></td>
<td>0.7</td>
<td>1.4</td>
<td>2.5</td>
<td>0.97</td>
</tr>
<tr>
<td>ATCC 13315</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>M. luteus</em></td>
<td>0.7</td>
<td>2.8</td>
<td>2.5</td>
<td>1.95</td>
</tr>
<tr>
<td>ATCC 7468</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>C. xerosis</em></td>
<td>0.7</td>
<td>1.4</td>
<td>25</td>
<td>7.81</td>
</tr>
<tr>
<td>IAL 105</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> not detected at all tested concentrations (0.17 to 2.8 mg/mL); <sup>b</sup> Results expressed as mg/mL; <sup>c</sup> Results expressed as μg/mL.

Figure 2: SEM images of *S. epidermidis* ATCC 12228. A: untreated bacterial cells, B: treatment with chloramphenicol, C: treatment with neomycin, D: treatment with triclosan D: treatment with essential oil of *O. vulgare*. "a": shows destroyed cells, "b": indicates aggregated/deformed cells.

Figure 3: SEM images of *P. vulgaris* ATCC 13315. A: untreated bacterial cells, B: treatment with chloramphenicol, C: treatment with neomycin, D: treatment with triclosan D: treatment with essential oil of *O. vulgare*. "a": cleft formation, "b": pore formation, "c": destroyed/deformed cells.
obtain antimicrobial properties against various species of microorganisms, especially pathogenic and food spoilage. Nonetheless, our study confirmed that this oil can also be a natural active as an alternative for usage in personal care products such as deodorants, due to its antimicrobial activity against the main bacteria responsible for bad perspiration odor. Its antibacterial properties are often associated with the phenolic compounds caracole and thymol and their precursors γ-terpinene and p-cymene. Those compounds frequently appear as the major components of this oil.

In the current study, the presence of all mentioned compounds, except thymol, was identified. However, this constituent could be included in the percentage observed in amounts of less than 0.1% which were not listed in this study. The proportion of thymol and γ-terpinene in the essential oil of O. vulgare can differ during the flowering and non-flowering stages of the plant. The increase of one of these constituents is accompanied by a decrease of the other and vice-versa. The author also suggests that this factor does not interfere in the content of the other two main compounds: carvacrol and p-cymene. reported the amount of carvacrol is much higher during the summer, while p-cymene predominates in autumn.
Accordingly, minor differences in the chemical composition of the essential oils can be due to physiological variation, soil types, genetic factors, vegetative stage, climate, harvest time, as well as cultivation and origin of the plants.\textsuperscript{32,35,36}

Who investigated five essential oils of oregano from different regions of Europe at different times of the year. A large variation in the chemical content of those oils was found. However, there was no significant difference in the antimicrobial activity against \textit{Salmonella enterica} serotype Enteritidis. On the other hand, the authors suggest that the essential oils containing carvacrol, \textit{p}-cymene, and \textit{γ}-terpinene may present a more effective antimicrobial effect.

Found carvacrol (66.9 g/100 g) as being the most prevalent compound\textsuperscript{37} in the essential oil of \textit{O. vulgare}, which also presented high content of \textit{p}-cymene (13.9 g/100 g) and \textit{γ}-terpinene (7.8 g/100 g). The authors suggest that phenolic active compounds, such as carvacrol, sensitize the cell membrane of the bacteria by complexation to available targets (amino acids and proteins) in the cells. Thus, when saturation of such site occurs, there is gross damage and leakage of intracellular constituents.

Found carvacrol (66.9 g/100 g) as being the most prevalent compound\textsuperscript{37} in the essential oil of \textit{O. vulgare}, which also presented high content of \textit{p}-cymene (13.9 g/100 g) and \textit{γ}-terpinene (7.8 g/100 g). The authors suggest that phenolic active compounds, such as carvacrol, sensitize the cell membrane of the bacteria by complexation to available targets (amino acids and proteins) in the cells. Thus, when saturation of such site occurs, there is gross damage and leakage of intracellular constituents.

Found carvacrol (66.9 g/100 g) as being the most prevalent compound\textsuperscript{37} in the essential oil of \textit{O. vulgare}, which also presented high content of \textit{p}-cymene (13.9 g/100 g) and \textit{γ}-terpinene (7.8 g/100 g). The authors suggest that phenolic active compounds, such as carvacrol, sensitize the cell membrane of the bacteria by complexation to available targets (amino acids and proteins) in the cells. Thus, when saturation of such site occurs, there is gross damage and leakage of intracellular constituents.

Found carvacrol (66.9 g/100 g) as being the most prevalent compound\textsuperscript{37} in the essential oil of \textit{O. vulgare}, which also presented high content of \textit{p}-cymene (13.9 g/100 g) and \textit{γ}-terpinene (7.8 g/100 g). The authors suggest that phenolic active compounds, such as carvacrol, sensitize the cell membrane of the bacteria by complexation to available targets (amino acids and proteins) in the cells. Thus, when saturation of such site occurs, there is gross damage and leakage of intracellular constituents.

According to the present study, the essential oil \textit{O. vulgare} demonstrated bactericidal activity against \textit{P. vulgaris} \textit{ATCC} (MIC=1.4 mg/ml), \textit{M. luteus} \textit{ATCC} (MIC=2.8 mg/ml) and \textit{C. xerosis} \textit{IAL 105} (MIC=1.4 mg/mL) and bacteriostatic activity for \textit{S. epidermidis} (MIC=2.8 mg/mL). Despite the fact that the essential oil from \textit{O. vulgare} obtained MIC values higher than the reference drugs, the present results are of interest due to the environmental impact and emergence of resistant bacterial strains associated with triclosan. Furthermore, the usage of antibiotics such as neomycin in deodorants is not recommended, as there are other active substances with lower toxic risks.\textsuperscript{38}

Examined the antibacterial properties\textsuperscript{39} of the essential oil of oregano against \textit{C. xerosis}, \textit{M. luteus} and \textit{P. vulgaris} by disk diffusion method. It was observed MIC=1/50 (v/v) for \textit{C. xerosis} and \textit{M. luteus} and MIC=1/200 (v/v) for \textit{P. vulgaris}. It has been hypothesized that the activity of the oil can be attributed to the presence of carvacrol, \textit{p}-cymene and \textit{γ}-terpinene.
According to oregano essential oil\textsuperscript{40} did not show antibacterial activity against \textit{S. epidermidis} A233. On the other hand, this oil was active in inhibiting \textit{P. vulgaris} Kukem-1329 with MIC=62.50 μg/mL.

Unlike many antibiotics, the hydrophobic constituents present in the oils from the \textit{Origanum} genus are able to gain access to the periplasm of Gram-negative bacteria through the porin proteins of the outer membrane.\textsuperscript{29,41} essential oil

Some studies employing SEM were found, showing the antibacterial effect of essential oil of \textit{O. vulgare} against several bacteria (\textit{S. aureus} ATCC 6538, \textit{B. subtilis} ATCC 6633, \textit{E. coli} ATCC 8739, \textit{S. aureus} and \textit{L. monocytogenes} ATCC QCF 7644).\textsuperscript{41-43} The authors observed injuries on the morphology of cell membranes. However, no studies were found demonstrating the detrimental effect of the essential oil of \textit{O. vulgare} against the microorganisms of interest by means of SEM.

It can be observed that the deodorant containing the essential oil from oregano demonstrated bactericidal action against all bacteria tested. SEM observations confirmed the physical damage and considerable morphological alteration to the bacteria treated with the deodorant.

Dermal and ocular toxicity of oregano essential oil.\textsuperscript{44} The essential oil at 3% did not cause skin and cutaneous irritations when administrated in wistar rats and albino rabbits and it was considered minimally toxic to the eye. In the present study, the developed deodorant contains 2% of the essential oil, percentage lower than the described study. Moreover, the addition of essential oil can improve the cosmetic properties of the final product, not only by protecting the consumer against bacterial infections, but also by contributing to the conservation of the formulation. Thus, it is also possible to reduce the usage of chemical preservatives and to formulate cosmetics with improved dermocosmetic properties.\textsuperscript{5,15}

\textbf{CONCLUSION}

Our results support the possibility of using the essential oil from \textit{Origanum vulgare} as a potential natural active antimicrobial to be applied in personal care products, such as deodorants. The usage of the essential oil from \textit{O. vulgare} in deodorants as an alternative to triclosan can encourage the personal care industry to search out new raw materials for formulations and to introduce innovations in their product lines.

\textbf{ACKNOWLEDGEMENTS}

The authors acknowledge the financial support from CAPES and CNPq. They are also grateful to MSc Amanda Garecz and Noêmia Rodrigues for the technical assistance and Adolfo Lutz Institute Culture Collection for standard strains donation.

\textbf{CONFLICT OF INTEREST}

The authors declare that there is no conflict of interests.

\textbf{REFERENCES}

20. Agiomyrgianaki A, Dais P. Simultaneous determination of phenolic compounds and triterpenic acids in oregano growing wild in Greece by \textsuperscript{31P NMR} spectroscopy.


