DE GRUYTER
OPEN

herba polonica
Vol. 59 No. 4 2013

DOI: 10.2478/hepo-2013-0030

REVIEW ARTICLE

Application of essential oils as natural cosmetic preservatives

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S u m m a r y

Nowadays, safety of chemical preservatives has been questioned by a big number of consumers. Traditionally used preservatives often cause skin irritation and lead to allergenic reactions. Growing demands for more natural and preservative-free cosmetics promoted an idea of the replacement of synthetic preservatives with essential oils (EOs) of antimicrobial properties. The antimicrobial effect of essential oil depends on content, concentration and interactions between the main active compounds. Effective preservatives should be characterized by a broad spectrum of antimicrobial activity at a minimum concentration. Formulations containing both types of preservatives: essential oil and a synthetic one have been tested and proposed as a compromise that allows for reducing concentration of both components due to their synergistic activity. Although most essential oils are regarded as safe, some of them may cause risk of contact allergy or phototoxic reaction. A well balanced risk-benefit assessment of essential oils is one of the great challenges for scientists or health policy authorities. This paper presents current state of knowledge on essential oils focused on their antimicrobial properties, the assessment of their efficacy and safety as cosmetic preservatives.

Key words: *essential oils, preservatives, antimicrobial activity, MIC (Minimum Inhibitory Concentration), challenge test*

INTRODUCTION

Pharmaceutical and therapeutic potential of essential oils (EOs) has been known since ancient times. EOs are obtained using several techniques: water or steam distillation, solvent extraction, expression under pressure, supercritical fluid or subcritical water extractions.

Nowadays, essential oils are the subject of intensive scientific research and also attract attention of cosmetic and pharmaceutical industries due to their potential as active pharmacological compounds or natural preservatives. Enormous diversity of this group of natural compounds and wide spectrum of biological properties make them attractive for many industries and new areas of application still has not been discovered. Regardless from sensory properties of essential oils, antimicrobial and antifungal activities are the goal of research. A new promising field of application of essential oils as natural preservatives in cosmetics or feed additives in human or animal food or as plant protection products has been studied.

It is estimated that more than 3000 essential oils are of commercial importance and used in flavour and cosmetic industries [1]. Trade of the most popular oils such as eucalyptus or lemon ones was calculated at over 1000 metric tons a year and their estimated value is several hundred million Euros [2].

The microbial safety of cosmetics has been always of special interest for industries, as microbial spoilage can lead to product degradation and cause a risk for consumers' health. Rich composition of modern cosmetics in combination with aqueous formulation and direct exposure to bacterial skin flora make them an ideal environment for growing of microorganisms. Taking into consideration the high risk of contamination and therefore a risk for consumers' health, the use of preservatives is a necessity. Moreover, bacterial contamination changes physical and chemical properties of cosmetics usually resulting in phase separation, discoloration and release of odours etc. Preservation systems prevent and control the growth of microorganisms from contamination during manufacturing, storage or consumer use. Completely preservative-free and microbial stable cosmetics are made by sterile production and appropriate packaging. However, satisfactory results can be achieved only for some formulations and are under certain restrictions: usually earlier expiration date, limited types of containers and special protective environment of production and packaging.

Preservative systems usually include various combinations of chemical biocides that operate on a broad spectrum of bacteria and fungi. They offer a high antimicrobial efficacy and therefore prolong the shelf-life of products, however, many of them can cause adverse reactions to skin. Parabens (PHB) or formaldehyde-releasing preservatives are the most widely used preservatives in cosmetic products. It was demonstrated that parabenes have weak estrogen-like properties [3]. Finding parabens in breast tumour cells and surrounding tissues provoked a discussion on the assessment of paraben safety and suggested a correlation between breast cancer and parabens [4]. Although results of detailed toxicity studies finally have shown that parabens are noncarcinogenic [5], consumers have been concerned and distrustful about them. PHB and formaldehyde-releasing preservatives like imidazolidinyl- and diazolidinyl-urea often cause skin irritation and provoke allergy reactions [6, 7]. Moreover, the problem of bacterial strains resistant to conventional preservatives has been observed in recent years. All these factors have contributed to a search for alternative preservative systems.

An idea of natural preservatives seems to be very promising and practical – plant derived compounds are readily available and environment-friendly. Nowadays much attention has been focused on essential oils that demonstrate antimicrobial activities and have been proposed as natural preservatives: tea tree (*Melaleuca alternifolia*), thyme (*Thymus vulgaris*), lemon grass (*Cymbopogon citratus*), oregano (*Origanum vulgare),* rosemary (*Rosmarinus officinalis*), calamint (*Calamintha officinalis*) or lavender (*Lavendula officinalis)* and many others.

The aim of this work is to present current knowledge on essential oils with special focus on mechanism of antimicrobial action, assessment of their efficacy as preservatives in cosmetic formulations as well as their safety.

Composition and mechanism of antimicrobial action of essential oils

Antimicrobial activities of EOs are well known and documented in numerous works. They are effective against both saprophytic bacteria and fungi, which are main source of cosmetic contaminations (*Bacillus* sp., *Micrococcus* sp., *Aereomonas sp.*, *Acinetobacter* sp. and *Aspergillus* sp. or *Penicillium* sp.) and also against human pathogens (*Staphylococcus* sp., *Streptococcus* sp., *Salmonella* sp. or *Candida* sp. and others). In contrast to antimicrobial activity of EOs mechanisms of their action are still not fully understood and need elucidation.

In general, antimicrobial activity of essential oils is determined by their composition and concentration of components. The number of constituents in essential oil can range from several up to far more than 100 [8]. Composition and proportion of compounds varies and depends on chemotype, age of a plant, climatic and environmental conditions as well as harvest time and the distillation method [9-11].

Essential oils are a complex and diverse group of natural compounds that usually consist of terpenes with terpenoids, and also aromatic and aliphatic compounds of low molecular weight. Monoterpenes are the most commonly found molecules constituting 90% of essential oils in a great variety of structures [1]. Aromatic compounds are represented less frequently, usually in trace amounts. EOs composition is often characterized by two or three main compounds at higher concentrations (20–70%), which determine biological properties of essential oil [1].

Antimicrobial activity of *Thymus vulgaris* is mainly derived from: thymol, carvacrol, γ- terpinene or p-cymene [12, 13], while *Melaleuca alternifolia* oil it is determined by terpinen-4-ol [14-16] and *Rosmarinus officinalis* oil by `1,8-cineole and α-pinene [17]. The studies of single components of essential oils demonstrated the most potent activity of phenolic compounds [18]. Strong antibacterial activity of these compounds is attributed to the presence of hydroxyl group in the phenolic structure. Ultee et al. [19, 20] demonstrated that hydroxyl group of carvacrol was responsible for the increase of membrane fluidity by changing acid and head-group composition in *Bacillus cereus* cells. It caused the depletion of intracellular ATP as well as it increased the permeability of cell membrane for K+, which resulted in death of bacteria cells. A more recent study on antibacterial mechanism of carvacrol and thymol against *E. coli* confirmed the disruption of membrane integrity, increased permeability and also leakage of protons and potassium ions [21]. The presence of free hydroxyl group in carvacrol and thymol caused depolarization of membrane and loss of potential. Differences in mode of action between esential oils (thyme, oregano and cinnamon) were demonstrated against *Listeria monocytogenes* [22]. Thyme and oregano, rich in thymol and carvacrol, caused death of bacteria cells by membrane damage whereas cinnamon oil acted without any severe damage of membrane which suggests a different mode of action. Similar effect of thymol and carvacrol results from its chemical structure – these two compounds are isomers that differ only in the position of a hydroxyl group. Moreover, the free hydroxyl group possesses a delocalized electron system allowing the release of a proton. Such a particular structure acts as a proton exchanger, thereby, reducing the gradient across the cytoplasmic membrane and resulting in depletion of the ATP pool and finally leading to cell death [20, 23]. In contrast, eugenol (main active compound of cinnamon oil) possesses a methoxyl group in an ortho position, disabling the OH group to release its proton easily [23]. Based on the aforementioned studies, the hypothesis of the key role of free hydroxyl group in the antibacterial activity has been confirmed.

Antibacterial activity of EOs may include several mechanisms of action; one of the well documented is membrane disruption by the lipophylic components. Terpenes and terpenoids are lipophylic compounds which pass through cell wall and cytoplasmic membranes disrupting their structure and permeabilizing them. Permeabilization usually initiates a cascade of reactions: loss of ions and reduction of membrane potential, collapse of proton pumps and depletion of ATP pool leading to death of cells. Damage of cell wall and membranes may result in leakage of macromolecules and lysis [24]. Some terpenoids with functional groups can also interfere with membrane-integrated enzymes like respiratory pathway enzymes inactivating them and interrupting vital functions of cells [25].

An efflux pump is a defence mechanism used by bacteria to pump out the harmful substances. *Pseudomonas aeruginosa* mutants with an impaired efflux pump were more susceptible to *Melaleuca alternifolia* oil and some monoterpenes than these with a fully active efflux pump [26]. More recent works documented the decreased production of virulent factors like enterotoxins, haemolysin, coagulase and shock toxins as well as reduced transcription levels of associated genes [27-30].

Recent studies provided an evidence that different mechanisms are involved in antibacterial activity of essential oils. Disruption and permeabilization of membranes is the best documented mode of action, the others are not fully understood and require more detailed studies.

EOs are also effective in controlling fungi, which is an important advantage of that preservative. It has been found that some EOs exhibit the highest potential against *Candida* species [31, 32] and *Aspergillus* sp. [32, 33]. The antifungal mode of action involving cytoplasmic membrane lesion by the disruption of sterol biosynthesis was documented in *Candida*, *Aspergillus flavus* and *Botrytis cinerea* cells [32-34]. Ergosterol is a specific sterol component of yeast cell membranes. It is responsible for cell integrity and maintenance of cell vital functions, which is a main target of antifungal compounds. Parveen et al. [35] analysed the gene expresion profile of *Saccharomyces cerevisiae* exposed to α-terpinen using DNA microarray to elucidate the mechanism of terpenes toxicity on yeast. The results showed the up-regulation of genes belonging to lipid and fatty acids metabolism, cell wall structure and organization, detoxification, cellular transport etc. Both disrupt permeabilization of membrane and inhibition of mitochondrial electron transport lead to reduced ATP depletion and enhanced accumulation of ROS in *Aspergillus flavus* which was documented by Tian [33]. The disturbances of mitochondrial respiratory chain and ROS accumulation are considered as signals for cell apoptosis. In general, possible cytotoxic mechanism of EOs involves the damage of mitochondrial membranes, changing the electron flow through the electron transport chain, with increase of ROS production.

Although antifungal properties of EOs are well documented, the exact molecular mechanism is still unknown. It is also assumed that other mechanisms, not involving the membrane disruption, play also a role in antifungal activity [36]. The cytotoxic effect of EOs affects many vital processes and may lead to the activation of different detoxification mechanisms and reactions, which are still uncharted.

Some EOs are also potent antiviral agents. Antiviral activity of different essential oils and isolated monoterpenes were confirmed against *Herpes simplex* viruses [37], cytomegalovirus [38, 39] rhinovirus [40], coronavirus [41] and adenovirus [42]. The mechanism and site of antiviral action are still unclear. It seems that there are different mechanisms of antiviral activity. Inactivation of HSV as effect of EOs activity has occurred before adsorption but not after penetration of viruses into host cells [43, 44]. Since viral envelopes are derived from membrane of host cells and EOs have a capacity of disrupt membranes, thus antiviral activity is probably related to the disruption of envelopes. Moreover, an adenovirus that lacks an envelope showed insensitivity to eucalyptus oil [42]. Some reports suggest different mechanisms. A specific inhibition of CMV early gene expression was observed after the treatment with *Euonymus* sesquiterpenes [39] or inhibited glucosylation of viral proteins as an effect of monoterpenes activity [38]. The antiviral activity of tea tree oil is attributed to its main compounds: terpinen-4-ol, terpineol and terpinolene [45]. Although single selected monoterpenes showed high antiviral activity (α-pinen and α-terpinen), the mixture of them in natural tea tree essential oils was ten-fold more effective [45]. Unlike the antibacterial effect, the antiviral activity of monoterpenes does not equally contribute to the antiviral effect of a given essential oil.

Antimicrobial activity of EOs results not only from the presence of main active compounds but also from interactions between different components. Synergism of thymol and carvacrol or both components with eugenol against *E. coli* strains has been observed [46]. The additive [47] and antagonistic [48] effects have also been noted, too. Synergism and additive effect is attributed to phenolic and alcohol compounds, whereas antagonism is explained as an interaction between non-oxygenated and oxygenated monoterpene hydrocarbons [49]. The mode of action of synergism is not clear, but some hypotheses have been proposed: synergistic effect is due to different modes of action of single compounds and thus they act on different targets of microorganism or the similarity of involved mechanisms enhances the antimicrobial effect [49].

Antimicrobial activity of EOs is a result of activity of many compounds and complex interactions between them. Their antimicrobial effect depends on content, concentration and interactions between main active compounds and also on the susceptibility of microorganisms.

Efficacy of essential oils as preservatives in cosmetic formulations

Efficacy of preservatives in cosmetic formulations is evaluated in a challenge test according to the European Pharmacopoeia guidelines. The challenge test is a standard procedure that involves artificial contamination of cosmetics with predetermined number of bacteria and fungi (10^5-10^6 viable cells ml^{-1} or g^{-1} of product) as well as periodic removal of samples at fixed time for counting of viable microorganisms present in the formulation during test [50]. Microorganisms used in the challenge test include strains of bacteria: *Staphyllococcus aureus*, *Pseudomonas aeruginosa*, *Escherichia coli* and fungi: *Aspergillus niger* and *Candida albicans*. According to EP, a topical preparation is well preserved if the number of the bacteria recovered per gram is reduced by a factor of 10^3 (criteria A) and 10^2 (criteria B) within 2 days of the challenge test with no cell proliferation at 7th day up to the 28th day. For fungi the factor is 10^2 in criteria A and 10^1 in criteria B within 14 days of the challenge [51].

An early study on the efficacy of *Thymus vulgaris* essential oil in two cream formulations in the challenge test revealed an unsatisfactory effect of preservation [50]. The required criteria were satisfactory against the bacteria strains and partially against yeast (only W/O formulation) but not against *Aspergillus niger* in spite of high concentration of thyme oil (3%). Samples of oil contained high concentration of thymol (38.6% and 43%), but were relatively low in carvacrol (9.8% and 2.2%). The authors assumed that probably the optimal ratio of both phenolic constituents of oil would be more effective in antifungal activity. Different behavior of thyme oil against *C. albicans* in two formulations (O/W – oil in water and W/O – water in oil) was explained by the reduced water bioavailability and higher pH in W/O preparation that could promote better fungicidal effect.

A study on *Artemisia afra*, *Pteronia incana*, *Lavandula officinalis* and *Rosmarinus officinalis* essential oils demonstrated the efficacy in reducing microbial contamination in aqueous cream formulation [52]. The population of tested microorganisms was markedly limited and controlled (criterion A and B) in the challenge test up to 7th day. The most effective was *A. afra* oil reach in thujone (53%) at all concentrations (0.5%, 1.0% and 1.5%). The authors noticed that EDTA used as chelator also contributed to the reduced viability of bacteria and fungi. This promotes further studies on a combined preservation system containing not only EOs but also EDTA, synthetic preservatives or surfactants.

Combination of *Calamintha officinalis* essential oil (1.0%) with 2mM EDTA in cetomacrogol cream resulted in good preservative activity and allowed for meeting all criteria of challenge test [53]. Effective preservation was achieved thanks to addition of EDTA that facilitated penetration of oil into bacteria cells and also to high concentration of carvon (64.3%), which is a main constituent of essential oils of strong antibacterial properties. In the next study *Calamintha officinalis* essential oil (1% and 2%) was applied alone in cream and shampoo formulations [54]. Preservation effect was limited to higher concentration of oil (2%), in cream preparation (satisfying criterion A) and in shampoo for criterion B of the challenge test.

The synergistic effect of essential oils (*Laurus nobilis*, *Eucalyptus globulus* and *Salvia officinalis)* with an addition of a synthetic preservative (methyl-p-hydroxybenzoate – MPB) and without it in cosmetic preparations was studied by Maccioni [55]. EOs (0.025% and 0.0125%) were applied alone, together and in combination with MPB in three formulations: carbopol cream (O/W), carbopol hydrogel and hydrolyte. The preservative was used at low concentration (0.01% and 0.001%, respectively) up to 20 and 200-fold less than usual amount (0.2%). However, preserving effect was achieved for variants with combination of MPB and two or three essential oils but not against all microorganisms. *Candida albicans* was resistant in cream and hydrolate formulations in spite of MPB presence. Synergistic effect of oils was confirmed in case of gram-positive bacteria, especially in hydrogel formulations. The results of this study proved that the application of combined essential oils is capable to reduce significantly the amount of synthetic preservatives in cosmetic preparation.

Complex preservative systems including EOs and synthetic preservatives or surfactants have been intensively studied and improved. A comparative study of efficacy of lavender, tea tree and lemon essential oils alone as well as combined with synthetic preservatives (1,3-dimethylol-5,5-dimethyllhydantoin and 3-iodo-2-propynyl butyl carbamate) in body milks (W/O) demonstrated clearly the synergistic effect of the composed preservative system making possible the reduction of level of synthetic preservatives up to 8.5 times [56]. Synthetic preservatives tested without essential oils at a lower concentration (0.1%) were ineffective against *Ps. aeruginosa* and *Candida sp*. in the challenge tests. The increased concentration (0.3%) resulted in body milk sanization within 14 days. The same preserving efficacy was achieved in tests on a mixture of lavender and tea tree oils (0.5% each) and synthetic preservatives at 0.1% concentration. A later study on the same essential oils and preservatives supplemented with solubilizer in washing liquid and body balm (W/O) confirmed the improved preservative effect [57]. Washing liquids containing essential oils (1.0 %) without preservatives and solubilizer fulfilled criterion A of the challenge test only for *S. aureus*, *Candida* sp. and *A. niger*, but in body balm the combination did not exhibit any preservative effect. An addition of 5% solubilizer (polysorbate 80) to tea tree essential oil resulted in increased bacteriostatic activity but not sufficient fungiostatic activity. A combination of tea tree oil (0.5%), solubilizer (5%) and synthetic preservatives (0.3%) in body balm formulations met criterion A of the challenge test, according to the EP standards.

A comparative study of preservative efficacy of herbal extracts, essential oils (*Lavandulla officinalis*, *Melaleuca alternifolia* and *Cinnamonium zeylannicum*) and methylparaben showed higher inhibitory activity of essential oils than synthetic preservative and extracts in cosmetic emulsion [58]. Cinammon oil (2.5%) was the most potent inhibitor of the growth of *S. aureus*, *E. coli* and *C. albicans*. Depending on tested microorganism strains, antimicrobial activity of essential oils (2.5%) was in some cases 3.5 times stronger than those of methylparaben (0.4%). This study demonstrated that it is possible to replace synthetic preservatives by essential oil, however, in relatively high concentrations.

A recent study on antimicrobial emulsion formulation containing collagen hydrolisate showed that formulation containing 2% *Thymus onites* essential oil was effective against tested bacteria and fungi in the disc diffusion method [59]. The author noticed that the formulation with antimicrobial effect had also the least favourable viscosity.

Most studies indicate better performance of EOs in combination with synthetic preservatives as well as chelators and solubilizers. The addition of EOs at relatively low concentration or EOs with solubilizers enables to reduce concentration of synthetic preservatives. When oil is applied alone, its antimicrobial activity is usually insufficient and higher concentrations are required to achieve a better effect. Such a high concentration of EOs leads to many problems like: phase separation, unfavourable viscosity of formulation and also strong undesirable odour. Each cosmetic formulation needs developing of a special composition and proportion of the selected essential oils and synthetic additives as well as appropriate concentration of all constituents to achieve synergistic effect. Moreover, it may contribute to allergenic reactions of skin or other health problems. Combination of EOs and synthetic preservatives allows for a reduction of the concentrations of both preservative agents and it seems to be a reasonable compromise. The aforementioned studies demonstrated biostatic effect of combination of synthetic preservatives and EOs in different cosmetic formulations. The main benefit of such a solution is the reduction of concentrations of the potential allergogenic ingredients and thus higher safety of products. Moreover, lower concentration of EOs causes better acceptance of cosmetic fragrances by consumers [56].

Nowadays, studies have been focused on the determination of the optimal combination of EOs and synthetic preservatives or surfactants [60] as well as on finding new, improved cosmetic formulations. The attempts to apply nanotechnology in encapsulation of essential oils have been done [61, 62]. Wattanasatcha et al. [63] made the first assessment of antimicrobial efficacy of free thymol and thymol loaded in nanoparticles. Their comparative study comprised free thymol, encapsulated thymol (ethylcllulose/methylcellulose coating) and methylparaben in cosmetic formulations i.e. lotion, gel and cream. The encapsulated thymol was an effective preservative as good as metylparaben (4 mg/ml), even when used at 12-25 times lower concentrations in all the cosmetic formulations. This study demonstrated antibacterial efficacy of thymol nanonspheres in cosmetic preparations and confirmed that nanoparticles did not deactivate antibacterial properties of the material. Moreover, nanoparticles dissolved in water very well. The search for the optimal solution with use of nanotechnology gave promising results but further detailed studies are necessary for successful application.

Safety of essential oils in topical application

EOs are usually considered as safe due to their natural origin. Being natural does not exclude toxic or allergic properties of plant derived products. Although most EOs are regarded as safe, some of them may cause risk of irritation, sensitization, phototoxicity or allergic reactions including anaphylaxis [64].

Toxicity of EOs can be rated as low or medium. EOs exert cytoxic effect in *in vitro* tests (human fibroblasts or dermal epithelial cells) at CC_{50} values from 5.0 to 1.950 μg/ml. It should be noted that antimicrobial effect of EOs is achieved when their concentration is about 20–20 000 μg/ml, which significantly exceeds cytotoxic range. Thus, adverse effects may be exerted at concentrations which do not show any antibacterial activity [65].

The most common adverse reaction is skin irritation and sensitization in contact with cosmetics containing EOs. Determination of the sensitizing agent is difficult due to the complex composition of oils and variability of constituents. The composition of oil may change significantly depending on chemotypes, climate or season conditions and harvest time leading to the synthesis of different metabolites and thus different toxicity [66]. Sensitization reactions are dose-dependent, higher concentration of oil has larger allergenic potential [67, 68]. Allergenic reaction develops after repeated exposure to an allergen. The threshold of irritation varies between species and depends on oil composition. The cases of sensitization to various EOs: ylang-ylang (*Cananga odorata*) [69], tea tree [68, 70], lemongrass [71], peppermint [72], lavender [73] and many other have been reported in literature. Most cases of allergy reported in Europe were caused by ylang–ylang and lemongrass essential oils as well as jasmine absolute [74]. The allergogenic components are linalool, limonene, bergapten, citral, coumarin, eugenol, geraniol and others [66]. The oxidation of oil constituents increases their sensitizing potential [75, 76], thus the storage conditions may affect the safety of cosmetic products.

Some plants from *Rutaceae* (bergamot, citrus, limes, orange or common rue) and *Apiaceae* (celery, parsley, carrot) families contain photoactive molecules like furanocumarins. The furanocumarins activated under ultraviolet A light bind to macromolecules forming mono- and biadducts that are cytotoxic. In some cases, they are capable to form the covalent adducts to DNA – leading to cell death or mutagenesis [77]. 5-Methoxypsoralen (5-MOP, bergapten), a component of bergamot oil, can induce skin cancer elicited by UVA light [78]. Apart from its phototoxicity, there are also reports concerning its anticancer activity, too [79, 80].

Some other components of EOs such as: pulgeone, safrole, methyleugenol, estragole showed carcinogenic properties in *in vitro* tests and in animal studies [81-84], although, there is no enough data about topical exposure in humans.

The EU law regulations concerning cosmetic products are defined in the Cosmetic Regulation No. 1223/2009, which came into force on 11th July 2013 [85]. The Regulation includes detailed requirements concerning product description, details of methods of manufacture and storage, product safety report, compliance with GMP (Good Manufacturing Practice), ingredient restrictions, pack labelling and notification. Prohibited or restricted substances in cosmetic products as well as permitted substances including preservatives have been listed in Ingredients Restrictions in Annex II–VI. Although EOs exhibit antimicrobial activity they are not registered as preservatives according to the Cosmetic Regulation. They are recognized as other ingredients by the European Scientific Committee and are not listed in Annex VI.

Taking into account antimicrobial activity and safety of EOs we can conclude they are generally safe compounds but we should remember that they are complex mixtures of constituents and some of them may be toxic or harmful.

CONCLUSIONS

Nowadays, more and more consumers have questioned safety of chemical preservatives. Traditionally used preservatives often cause skin irritation and provoke allergenic reactions. Growing demand for natural and preservative-free cosmetic products prompted an idea of the replacement of synthetic preservatives with natural compounds of antimicrobial properties. EOs have been considered as promising candidates. Although excellent antimicrobial properties have been confirmed for some of them, the studies on application essential oils in cosmetic formulations as preservatives have not brought satisfactory results. The most promising candidates for preservatives are: tea tree, lemongrass, oregano and clove, which show activity against a wide range of gram-positive and gram-negative bacteria (with exception of *Pseudomonas aeruginosa*), with MICs lower than 1%. Formulations including essential oil and synthetic preservative have been tested and proposed as a compromise that allows for reducing concentration of both components due to their synergistic activity. Although the efficacy of such combined formulation was documented in several cases, the question about safety was raised. EOs have a multipurpose potential, however, it should be noted that they are mixtures of multiactive compounds that may also possess undesired properties. A well-balanced risk-benefit assessment of essential oils is a challenge for scientists or health policy authorities.

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ZASTOSOWANIE OLEJKÓW ETERYCZNYCH JAKO NATURALNYCH ŚRODKÓW KONSERWUJĄCYCH W KOSMETYKACH

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S t r e s z c z e n i e

Bezpieczeństwo stosowanych obecnie syntetycznych środków konserwujących jest kwestionowane przez coraz większą rzeszę konsumentów. Przypadki reakcji uczuleniowych oraz potencjalne ryzyko wystąpienia innych problemów zdrowotnych spowodowało rosnące zapotrzebowanie na naturalne i pozbawione środków konserwujących kosmetyki. Zainicjowało również ideę zastąpienia syntetyków przez olejki eteryczne o właściwościach przeciwdrobnoustrojowych. Wyniki badań pokazują, że formulacja zawierająca zarówno olejek eteryczny, jak i syntetyczny środek konserwujący pozwala zmniejszyć stężenie obu czynników i dzięki temu osiągnąć lepszy efekt. Chociaż większość olejków eterycznych uważana jest za substancje bezpieczne, to niektóre z nich mogą powodować ryzyko uczuleń lub reakcji fototoksycznej. Dobrze skalkulowana ocena korzyści i ryzyka jest jednym z wyzwań stojących przed naukowcami oraz instytucjami zajmującymi się polityką zdrowotną. Artykuł prezentuje aktualny stan wiedzy na temat olejków eterycznych, ze szczególnym uwzględnieniem ich mechanizmu działania, skuteczności konserwującej w produktach kosmetycznych, a także kwestię bezpieczeństwa ich stosowania.

Słowa kluczowe: *olejki eteryczne, aktywność przeciwdrobnoustrojowa, MIC (minimalne stężenie hamujące), challenge test*