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NATURAL EXTRACTS USED TO PREVENT MICROBIAL CONTAMINATION OF COSMETIC PRODUCTS

BY

MIHAIL VÎNAGĂ, CORINA CERNATESCU and ALEXANDRA CRISTINA BLAGA*

"Gheorghe Asachi" Technical University of Iaşi, "Cristofor Simionescu" Faculty of Chemical Engineering and Environmental Protection, Iaşi, Romania

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Abstract. The antimicrobial effect of some plants has been known since ancient times and is the subject of scientific investigations even today, being sometimes the reason for their use in cosmetics. Over the years, a deeper understanding of the behavior of skin and plants has become available, drawing increasingly complex images. Plants are complex organisms that produce different metabolites as response to the environment in which they live, and plant extracts and essential oils (when applied to the skin) interact with skin cells and increase the well-being and appearance of the skin. Ethnobotanical studies and physico-chemical analyzes have presented a rich inventory of plants with the potential to enrich and improve modern cosmetics. Recently, a number of laboratory studies have revealed the efficiency of plant extracts and phytochemicals as antimicrobials. The most used plant materials that provide antimicrobial protection includes: essential oils (rosemary, tea tree, turmeric and rosehip seed oil), plant extracts (rosemary, rosehip, sage, lemon balm, green tea, *Kaempferia galanga, Neem leaf* and *Horseradish* extract), isolated oil and phytochemicals such as cinnamate, benzoate, eugenol.

Keywords: Natural extracts, cosmetics, bioactive compounds, antimicrobial effect, plants.

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*Corresponding author; *e-mail*: acblaga@tuiasi.ro

1. Introduction

The cosmetic industry has worldwide developed in the last 10 years and its growth continues due to consumers high demands for innovative products, but also quality and efficiency. According Future Market Insights (FMI), the global market for natural cosmetics is constantly growing, and in 2027 it is estimated that it will reach a value of 54 billion dollars, with 2 key elements driving this growth: consumer concern about the side effects of chemicals in cosmetic products and growing interest in the benefits of natural ingredients. Recently, an increase interest regarding personal health and safety generated a higher request for cosmetics free of harmful chemicals. Hence, companies are new focused on replacing chemicals with natural vegetable, mineral or marine ingredients, that can be introduced in a single cosmetic formula, in different manners: active ingredients, excipients, and additives (Kerdudo *et al.*, 2016; Campana *et al.*, 2006). Moreover, more awareness is rised related to the importance of mantaining a healthy skin microflora (skin microbiota), so important in protecting the organism against harmful pathogens.

Microorganims can develop in cosmetics products both during manufacturing and during their use, as they can be found in diffrent raw materials or manufacture environment, but also in the packaging materials. During their use, even before its fisrt use, cosmetics products are often exposed, either in shops or even at home, to temperature higher than recommended thus facilitating microbial growth. Furthermore, after opening the cosmetic product, due to product contact with consumer skin (microbiom) and environment, it is highly susceptible to further contamination. If viable conditions are met, especially presence of water in the product, microorganisms can grow and multiply hence causing product quality modifications (unpleasant odour or color chages, active compounds degradation), resulting an instable products that it can be even dangerous for its users (Lee *et al.*, 2012). One manner to prevent these modifications imply the use of preservatives to prevent microbial infections in product and subsequently in the consumers, for their valability period (J. Eur. Union (2009), L342/59).

The p-hydroxybenzoic acid, imidazolidinyl urea and phenoxyethanol, are synthetic preservatives used for many years to extend cosmetic products lifespan preventing microbial growth, have an affordable price, are compatible with other ingredients (they do not affect formulations colour or flagrance), and offer a broad-spectrum activity against microorganisms at very low concentrations. However, recently, these chemical compounds use has been reduced due to public concern for their use, related to promoting irritations on damaged or sensitive skin (Kerdudo *et al.*, 2016). An important exemple is 4-hydroxybenzoic acid esters, or parabens (usen in about 80% of cosmetics), that have been associated with increased incidence of breast cancer due to its ability to mimic estrogen.

Parabens are colorless, odorless, well tolerated by the skin as they are effective in very low dosage. Following the controversies about parabens and phenoxyethanol (associated with suspected reproductive and developmental toxicity), cosmetic companies need to find and use natural preservatives (Fernandez *et al*., 2012). The use of these natural ingredients offers a market advantage (as consumers are searching for natural products) and provides a healthier alternative. Moreover, several natural compounds with antimicrobial properties, that can have other properties (*i.e.*, antioxidant) are not mentioned in the legislation as preservatives (Annex V of Regulation (EC) (J. Eur. Union (2009), L342/59), offering the possibility to sell a "preservative free" product. Increasing consumer demand for natural products can cause manufacturing companies to analyze different natural molecules that can fulfill the role of preservative in relation to the biodiversity that surrounds us (Kerdudo *et al*., 2016). The aim of this review is to present natural extracts that can be used for cosmetic products as replasments of sinthetic preservatives.

2. Natural extracts - properties of extracts

Plant extracts are absolutely necessary ingredients in a natural cosmetic product. These can be based on extracts from flowers, fruits or vegetables, the basic product being processed in such a way that it takes on a form that can be mixed into the cosmetic product, offering the benefits of the fruit or plant, almost as if they were used in their original state. their natural. Fruits, vegetables or flowers are rich in antioxidants, vitamins and nutrients, and they must be able to reach the skin and, more than that, provide the expected results. The use of bioactive vegetable compounds from plants is mainly conditioned on the selection of the appropriate extraction method, since this is the first step of processing (extraction methods are sometimes referred to as "sample preparation techniques") with a significant role in the end result (Wink, 2003). The development of modern chromatographic and spectrometric techniques makes the analysis of the bioactive compound easier than before, but of great importance is the selection of an appropriate extraction method, the input parameters and the exact nature of the plant parts. The most common factors that affect the extraction processes are the properties of the plant part matrix, the solvent, temperature, pressure and time. An increased understanding of the dynamic chemical nature of various bioactive molecules is essential for the progress of bioactive analysis. Due to important technological and technical improvements, an increased interest bioactive natural molecules was observed in cosmetics and pharmaceuticals, food additives and even pesticide sectors. Typically, bioactive compounds remain together with other compounds present in plants. Bioactive compounds can be identified and characterized in different parts of plants, such as leaves, stem, flower and fruit or seeds.

2.1. Classification and synthesis of bioactive compounds

The bioactive compounds classification is still inconsistent, depending on a particular classification intent. According to Croteau *et al.* (2000) bioactive plant compounds can be classified into three main categories, as seen in Fig. 1.

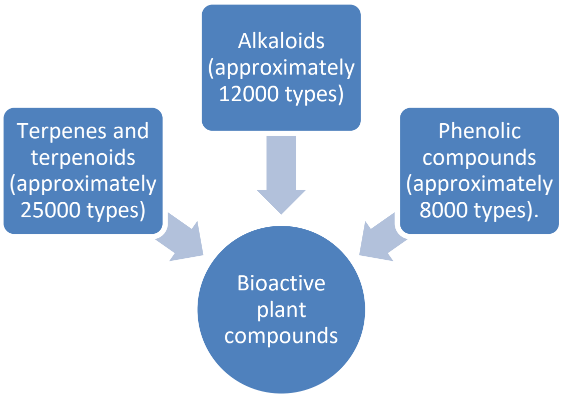

Fig. 1 – Bioactive plant compounds classification by Croteau *et al.* (2000).

Most bioactive compounds have particular structural characteristics that arise from their biosynthesis, the main four pathways being:

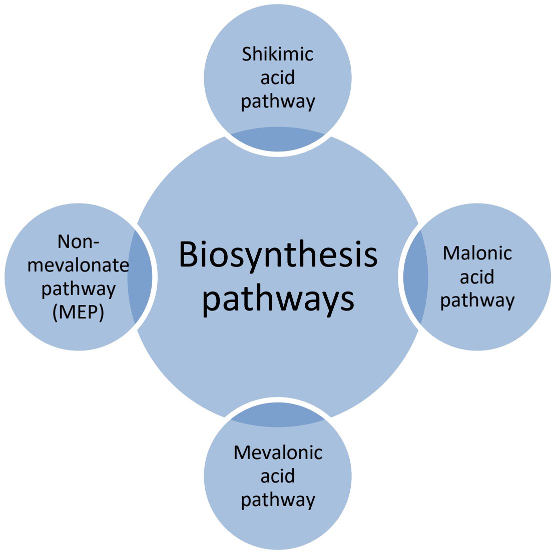

Fig. 2 – Main biosynthesis pathways for bioactive compounds that can be used as preservatives in cosmetic products.

From aromatic (shikimic acid pathway) and aliphatic amino acids (citric acid cycle), alkaloids are produced, while from shikimic acid and malonic acid pathways phenolic compounds are synthesized, and terpenes are produced by the mevalonic acid pathway and the MEP pathway (Azmir *et al*., 2013).

2.2. Active ingredients from plants with antimicrobial activity

2.2.1. Eugenol

Eugenol (volatile phenolic compound with antioxidant effect) is the main constituent (70 - 90%) in cloves oil and one of the main components generating cloves aroma. The main sources of eugenol are Indian clove, basil and cinnamon, which are widely used as flavoring agents and preservatives in food, beverages and cosmetics. Eugenol is an antiseptic and anesthetic (local anesthesia used in dentistry), but it posses many pharmacological activities, such as antifungal, antibacterial and anti-inflammatory, but can also be used as a flavor. Due to its poven efficiency effective against *Salmonella sp., Listeria monocytogenes, Shigella sp., Clostridium botulinum,* and *Escherichia coli* it is used in several dental materials (zinc oxide-eugenol applied in dentinal cavity facilitate pulpal healing) or touth paste (de Souza *et al*., 2015).

2.2.2. Thymol

Thymol is one of most important ingredients found in thyme essential oils (main monoterpene phenol). It has antibacterial and antifungal properties, but it is also known as immunomodulator and antioxidant. Thymol is active against *Salmonella* and *Staphylococcus* bacteria, the inhibitory effect being attributed to microorganisms membrane integrity damage which further affects inorganic ions equilibrium (Barbosa *et al*., 2020). Thymol is a compound that has a distinct pungent aroma and slightly spicy taste. Thymol generally functions as an ingredient in personal care products including toiletries, skin care, hair care, hair dyes, toothpaste, mouthwash, etc.

2.2.3. Aldehydes

Hexanal and benzaldehyde are found in fruits and vegetables, and have enzyme-inhibition activity and antimicrobial properties, but are volatile and susceptible to degradation by oxidative reactions. They are used as fragrance, α, β-unsaturated aldehydes have a broad antimicrobial action, being active against both Gram-positive and Gram-negative bacteria (Saeed *et al*., 2019).

2.2.4. Carvacrol

Carvacrol, a phenolic compound with antioxidant properties, is considered one of the main components of savory, thyme and oregano essential oils. Its antimicrobial activity especially against *Escherichia coli* O157:H7 is related to the plasma membrane disruptive action, influencing intracellular ATP content (Takahashi *et al*., 2021). The carvacrol contained in oregano essential oil is used in the cosmetic industry as a fragrance, as well as a component of soaps, creams and perfumes.

2.2.5. Vanillin

Vanillin, a phenolic compound (phenolic aldehyde) present in vanilla pods (*Vanilla planifolia* or other species), has many industrial applications in food, pharmaceuticals, and cosmetics (especially perfumes). Only 1 - 2% of the used vanillin is natural, due to its high cost, synthetic vanillin obtained from ferulic acid, eugenol through biotechnological processes or even sinthetic is the other 98 - 99%. Researchers have documented inhibitory activity against fungi and bacteria (*Bacillus*, *Escherichia*, *Klebsiella*, *Listeria*, *Salmonella*, *Staphylococcus*, and *Serratia)* (Celik *et al.*, 2021).

2.2.6. Allicin

Allicin is an important organosulphuric compound found widely in garlic, with various health-promoting effects, such as antibacterial, antifungal, antiviral and anticancer effects, also decreasing blood preasure. The chemical mechanisms underlying the antimicrobial activity of allicin are poorly understood, but it is known to alter the free amino acid cysteine by forming allyl disulfide species. The antibacterial properties of allicin are long known, dilute allicin solutions inhibiting the growth of both Gram-negative and Gram-positive bacteria (Marchese *et al.*, 2016).

2.2.7. Cinnamaldehyde

Cinnamaldehyde, a yelow organic active constituent in cinnamon (cinnamon essential oils), used in cosmetics (aftershave lotions, mouthwashes and breath fresheners, toothpastes, lipsticks, moisturizers, or bath products) as flavorant and fragrance agent. The antifungal properties of cinnamaldehyde and its derivatives are well established. Cinnamaldehyde and its derivatives have been tested against several pathogenic fungi and have been shown to have antifungal activity against *Aspergillus flavus, Aspergillus fumigatus, Trichophyton rubrum, Coriolus versicolor, Laetiporus sulfuros* and *Aspergillus ochraceus* (Doyle and Stephens, 2019).

2.2.8. Alkaloids

Alkaloids are considered the largest class of natural compounds produced by plants, which usually contain one or more nitrogen atoms in their structure, heterocyclic organic substances with a basic character that can be used in cosmetics in low concentrations. In general, alkaloids are known as plant defense molecules and are extremely effective in keeping dangerous herbivores away. In cosmetics alkaloids as caffeine, capsaicin, spilanthol, berberine, anatabine, and piperine can be used in tonics, face and hair masks, creams, and lotions. Alkaloids inhibit the growth of both Gram-negative and Gram-positive bacteria (Cushnie *et al.*, 2014).

2.2.9. Anti-microbial peptide

Plant antimicrobial peptides include proteic compounds produced in plants, such as: snakings, defensins, glycine-rich proteins, puroindolines, hevein-type proteins, cyclotides. Plant antimicrobial peptides (host defense peptides), first discovered in 1942 (purothionin from wheat flour) function as natural defense compounds in microorganisms, and plants (flowers, roots, leaves, stems, and seeds). These compounds have a broad-spectrum against enveloped viruses, bacteria (Gram-negative and Gram-positive), and fungi, but they also exhibit antioxidant effect, pro-collagen and self-renewal effects, being used especially in topical products. Purionin has been shown to be active against *Corynebacterium flaccumfaciens, Xanthomonas phaseoli, Erwinia amylovora,* and *Pseudomonas solanacearum,* (Tang *et al.*, 2018).

2.2.10. Citral

Citral is an oxygenated derivative of terpenes, usually found as a mixture of two isomers: geranial or citral A (trans isomer) and neral or citral (cis-isomer). Citral is the main active component of citronella oil, present in the plants leaves and fruits, and has broad-spectrum antibacterial activity. It has been recognized by the European Commission as a seasoning component in food (EU 872/2012), and approved by the U.S. Food and Drug Administration for application. A large number of studies have shown that citral can damage the mitochondria of *Aspergillus flavus* and *Penicillium digitatum* by destroying cell morphology. For some pathogens (such as *Staphylococcus aureus*, *Bacillus cereus, Listeria monocytogenes* and *Escherichia coli*), citral also exhibits good antibacterial activity. In addition, citral possesses antioxidant, anti-inflammatory and insecticide effect (Ju *et al*., 2020).

2.2.11. Saponins

Saponins are high molecular weight glycosides that are present in plants and marine organisms. Root of *Acanthophyllum* is a rich source of saponin, a natural biosurfactant with high potential applications in food industries. However, saponin is extracted from several natural sources such as *Ziziphus spina-christi*, *Glycyrrhiza glabra* root, plum and strawberry fruits, but *Acanthophyllum glandulosum* root is the primary source of saponin.

Saponin is known as defense system of the plants toward pathogenic microorganisms and has tri-terpenoids or steroid glycosides which that conjugates to sugar chains (one or more), with glycoside bond in its structure. Saponin is a non-ionic natural emulsifier, due to its high surface tension reduction activity between two immiscible fluids which that increase its applications extensively in food, cosmetics, detergents and pharmaceutical industries. Furthermore, saponin has hemolytic activity, anti-inflammatory, antifungal and adjuvant properties. Saponin has antibacterial properties on *Staphylococcus aureus* and *Escherichia coli* (Najjar-Tabrizi *et al.*, 2020).

2.2.12. Flavonoids

Flavonoids, hydroxylated phenolic substances with antioxidant properties, isolated from fruit, vegetables, and medicinal plants, have been extensively stuydied and include flavones, flavanones, flavan-3-ols, flavonols and anthocyanins. Flavonoids are secondary metabolites with anti-inflammatory, antiviral, and anticancer activities that posses in vitro effective antimicrobial action against a several microorganisms. The antimicrobial activity of polyphenols has been documented, flavonoids inhibiting the growth of both

Gram-negative and Gram-positive bacteria. Compounds that contained hydroxyl groups in ring B (3',4',5'- tri-hydroxyflavonoids) and flavanone aglycones showed sctivity against *Staphylococcus aureus* and 3-methoxy flavones (substituted at C-5 and C-7 with hydroxyl groups) showed activity against *B cereus*. Favones apigenin, saponarin, and vitexin were active against *E coli, P. aeruginosa, P vulgaris, and K. pneumoniae* (Saeed *et al*., 2019).

2.2.13. Quinones

Quinones are aromatic rings with two ketone groups, secondary metabolites isolated from microorganism and plants, derived from the oxidation of hydroquinones. They are highly reactive and common in nature, benzoquinone or hydroquinone can be used against *Staphylococci* or *Propionibacteria,* in cosmetic products against acne. Quinones inhibit the development of *Aspergillus flavus, Candida albicans, Cryptococcus neoformans* and *Rhotorula pilimana* (Subedi *et al*., 2018).

2.2.14. Tannins

Tannins are natural antioxidants, polymeric phenolic substances, that are encountered as a common ingredient in skincare products (toners, cleansers, or cosmetic products for oily skin or hair). Ellagitannin (molecular weights ranging from 500 to 3000) is a general descriptive name for a group of tannins, that are separated from bark, leaves, fruits, and plants roots. Condensed tannins have shown antimicrobial activities against *Escherichia coli, Stahylococcus aureus, Salmonella typhimurium*, *Bacillus subtilis, Shigella sonnei, Escherichia coli, Candida albicans,* and *Klebsiella pneumonia*. They action is related to bacterial cell wall binding thus inhibiting their growth (Saeed *et al*., 2019).

2.2.15. Coumarins

Coumarins are phenolic with antimicrobial activity against fungi, but also on bacteria. Benzo-2-pyrones are the simplest of the group of naturally coumarins, being produced as a secondary metabolite in many families of plants such as *Asteraceae, Apiaceae, Fabiaceae, Rosaceae, Rutaceae, Rubiaceae,* and *Solanaceae*. Natural products with a coumarinic moiety have been reported to have biological activities, such as: including anticancer, antioxidant, antiinflammatory and antiviral. Some coumarin derivatives conjugated with nitrogen-containing heterocyclic moieties, such as triazole and pyridine, were synthesized and proved to possess antibacterial bioactivity. Thus, hybridizing the coumarin nucleus with other moieties lead to new molecules with improved antimicrobial activity profiles.

Coumarins and its derivatives have antibacterial activity against Gram-negative bacteria: *Escherichia coli* and *Flavobacterium cloumnare* as well as Gram-positive ones: *Staphylococcus aureus* and *Staphylococcus agalactiae* (Hu *et al*., 2018).

2.2.16. Caffeic acid

A simple phenolic compound with some intriguing biological properties, such as antibacterial, fungicidal, and antioxidant, is called caffeic (3,4-

dihydroxycinnamic acid). Antibacterial activity against *Staphylococcus aureus, Klebsiella pneumoniae,* and *Staphylococcus epidermidis* has been noted (Saeed *et al.*, 2019).

2.3. Natural extracts with antimicrobial activity used in cosmetics

The skin is covered with different microorganisms (microflora), just as all biological materials. For some persons and under specific circumstances, the skin microflora expands invasively and sets off pathological processes that result in acne, infections, and rashes. Additionally, infections of the mouth and the scalp are brought on by the invasive growth of specific microorganisms. Some microorganisms that are prevalent in the skin, hair, and nails can also cause smells and irritants, which can negatively impact general health and wellbeing. Antimicrobials have functional applications in deodorants, cleaning formulations, and formulations for oral and topical protection.

Skin pathogen examples comprise several microorganisms: one exemple is a bacteria linked to acne and other skin infections: *Propionibacterium acnes,* one other is *Staphylococcus aureus*, a bacteria discovered in infected wounds and rashes, including acne, or *Staphylococcus epidermidis*, a bacterial strain that is discovered in a variety of oportunistic bacterial skin infections, including acne, as well as *Corynebacteria* and microorganisms that cause body odor. Examples of oral pathogens include the bacterial strain *Streptococcus mutans*, which has been linked to tooth decay. Examples of dandruff-related pathogens include *Pitysporum ovale* (*Malassezia furfur*, a yeast strain).

The iresponsible application of conventional antibiotics results in microorganism strains that are resistant to those antibiotics. Natural products that effectively limit the growth of microorganisms are therefore required. The versatility of natural extracts combined with immunological, anti-inflammatory, and wound healing support are major benefits for natural extract use in cosmetics.

Numerous laboratory investigations conducted over the past years have demonstrated the potency of antimicrobial plants and chemicals. These qualities are explained by the presence of secondary metabolites, such as tannins in plant extracts and phenolics in essential oils. Examples of different types of natural substances that offer antimicrobial protection include essential oils like rosemary, tea tree, and turmeric oils; herbal extracts like rosemary, sage, green tea, lemon balm, *Kaempferia galanga*, and neem leaf; and isolated phytochemicals like eugenol, benzoates, and cinnamates. In vitro techniques like broth dilution, disc or agar diffusion, and agar overlay assays are frequently used to test the antimicrobial activities of natural extracts and phytochemicals in order to establish the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) of each treatment.

2.3.1. Coleus oil (*Coleus forskohlii* root oil)

Coleus oil is an essential oil extracted from the roots of *Coleus forskohlii*, a plant from *Lamiaceae* family (related to mint and lavender). The extract is considered safe for cosmetic formulations (emollient, masking and skin conditioning) use because it doesn't irritate the skin and combines well with cosmetics thanks to its pleasant woody aroma. *Coleus forskohlii,* the main source of forskolin (used in cosmetics as it promotes healthy skin cell division, support normal immune activity in the skin, but also for treating allergies, burns, wounds, and insect bites), gained pharmacological importance. This oil contains 3-decanone (about 7%), bornyl acetate (about 15%), sesquiterpene hydrocarbons and sesquiterpene alcohols, ß-sesquiphellandrene (about 13%) and γ-eudesmol (12.5%). Its antimicrobial properties of the oil render it useful in topical preparations.

Coleus oil was found more effectively to inhibit the growth of bacterial skin pathogens: *Propionbacterium acnes*, *Staphylococcus aureus* and *Staphylococcus epidermidis* and against *Candida albicans* yeast (Loftus *et al*., 2015).

2.3.2. *Kaempferia galangal* (*Kaempferia galanga* root extract)

In Southeast Asia, two members of the *Zingiberaceae* family – *Kaempferia galanga* (smaller galangal, kencur) and *Alpinia galanga* (bigger galangal) – are used as spices and medicinal herbs, but in cosmetics they are prize for maintaining skin in good condition, being used in bar soaps, and skin care products due to anti-acneic, antimicrobial, and anti-effects. The primary components of the essential oil are ethyl-p-methoxycinnamate (30%), p-methoxycinnamic acid, and ethyl-cinnamate (25%). Ethyl-p- methoxycinnamate is an important antifungal but also antibacterial (inhibit the growth of *Propionibacterium acnes*, at concentrations lower than 0.5%) (AlSalhi *et al*., 2020).

2.3.3. Turmeric oil (*Curcuma longa*)

The ginger family includes the ancient powdered spice known as turmeric (*Curcuma longa*), that offers a variety of medical and aesthetic advantages. Curcumin, the active component, is a natural antiseptic with antibacterial and antimicrobial qualities. It treats eczema and acne and cures and prevents dry skin. Traditional uses of turmeric include Hindu festivities as well as daily face and hair maintenance. It has also been demonstrated to delay the development of wrinkles and the aging process.

By steam distilation or solvent extraction from the rhizome of *Curcuma longa* (family *Zingiberaceae*), turmeric oil is produced. Steam distillation of *Curcuma longa* produces up to maximum 7.2% turmeric oil (with main constituents turmerone (60%) and related compounds, and zingiberene (25%)), known for its amazing health and beauty benefits. Studies have shown that turmeric essential oil is just as beneficial as turmeric. It is rich in antioxidants and has strong anti-inflammatory properties as well as anti-allergic, anti-bacterial, antimicrobial, anti-mycotic qualities, which act miraculously on the skin and hair

(Ren *et al*., 2021). Stanojević *et al*., 2015 tested the antimicrobial effect of tumeric oil for *Candida albicans* and four bacterial strains: *P. vulgaris* and *K. pneumoniae* (Gram-negative) and *B. cereus* and *B. subtilis* (Gram-positive), obtaining the highest antimicrobial effect on *C. albicans* (31 mm inhibition), followed by B. subtilis (24 mm) and *P. vulgaris* and *K. pneumoniae* (15 mm, 18 mm respectively) (Stanojević *et al*., 2015).

2.3.4. Oleuropein: (*Olea europaea* (olive) leaf extract)

The principal active ingredient in olive leaf is a family of split iridoid glycosides, which also includes flavonoids and their glycosides, tannins, and other low molecular weight substances. Oleuropein and hydroxytyrosol, which are commonly found in cosmetics and health care products, have the highest activity in olive leaf extract, which is mostly made up of iridoid bitter compounds. High quantities of oleuropein are mostly found in skin care products since they can successfully preserve the skin's softness and elasticity and have a skin-rejuvenating impact. Oleuropein is a polyphenololide compound, which makes up around 19% (w/w) of virgin olive oil, is the main phenolic component extracted from olive leaf and have been shown to have a variety of anti-microbial effects in vitro, with its associated compounds. It has been demonstrated that it inhibits the growth of *Bacillus cereus, Staphylococcus aureus, Pseudomonas syringae*, and several other bacterial species when used in vitro. For instance, *Staphylococcus aureus'* growth in nutritional media was delayed by the presence of low concentrations (0.1% w/v) of oleuropein, whereas the presence of higher concentrations (0.4-0.6% w/v) completely prevented growth.

Oleuropin has bactericidal properties to a variety of Gram-positive and Gram-negative bacteria, however it is ineffective for yeast. Both in vitro and in vivo tests have proved antiviral properties. Although the precise mechanism of antimicrobial action is yet unknown, Oleuropein and related compounds disrupt the membranes of microorganism as well as the production of amino acids that are crucial for viral replication (Gholamhosseini *et al.,* 2020).

2.3.5. Neem oil and Neem leaf extract (*Melia azadirachta*)

The neem tree, *Azadirachta indica*, has been used for thousands of years as a traditional treatment for a wide range topical skin condition, including eczema, psoriasis, rashes, acne, dry skin issues, burns, and abrasions. Along with its healing abilities, it is also rich in fatty acids and glycerides, making it a fantastic natural moisturizing base for skin care formulas. The miracle treatment for psoriasis may be neem seed oil and leaf extracts. The scale and redness of the spotty lesions are diminished, and the itching and agony are also subsided. Neem seeds and leaves produce limonoids, which have a variety of biological applications, including antibacterial, antiviral, and insect repellant properties. *Staphylococcus aureus* was inhibited by seed oil at a concentration of 0.3% on agar plates, and *Salmonella typhosa* at a concentration of 0.4%. On agar plates, seed oil was active against *E. coli* and *Proteus* species at a concentration of 3%; it was also active against *Klebsiella pneumoniae* at a concentration of 6.0%.

Methanol and butyl methyl ether extracts shown antifungal activity against a variety of fungal species, including *E. floccosum, M. canis, M. gypseum, T. concentricum, T. entagrophytes, T. rubrum, and T. violaceum*. A recent study used commercially available chlorhexidine gluconate (0.2% w/v) as a positive control to test the effectiveness of a muco-adhesive dental gel containing Azadirachta indica leaf extract (25 mg/g). The study's findings indicated that when compared to the control group, the dental gel with Neem extract significantly reduced the plaque index and the amount of bacteria (Blum *et al.*, 2019).

2.3.6. Green tea extract (*Camellia sinensis* leaf extract)

The leaves of the *Camellia sinensis* tea plant, are used to make green tea extract. Polyphenols, which are known to be powerful free radical scavengers, and other components found in green tea extracts are beneficial for the skin. Green tea extract is thought to have qualities that make it advantageous for treating and maybe preventing a variety of skin-related issues since it is high in polyphenols, catechins, and caffeine. When applied topically, it lessens the appearance of cellulite, soothes redness and swelling, evens out discolouration, calms irritation, heals damage, exfoliates, lessens the look and incidence of blackheads, and lightens the appearance of dark circles. *Staphylococcus sp.* and *Yersinia enterocolitica* were found to be inhibited by the catechins in green tea. Drug-resistant bacteria strains were found to become more susceptible to phenicol when exposed to green tea extracts. Studies conducted in vitro on specific antibiotic-resistant strains of *Staphylococcus aureus* showed that penicillin resistance might be reversed by adding green tea extract. The minimum inhibitory concentration (MI) of oxacillin and other beta-lactamases was discovered to be significantly reduced by epoxide gallate. *Escherichia colitis, Streptococcus salivarius,* and *Streptococcus mutan*s, microorganisms prevalent in the saliva and teeth of people with dental caries, were found to be strongly inhibited by intake of green tea. The decreased barrier function in microorganisms and the depletion of thiol groups are connected to the increased antimicrobial activity of green tea (Armstrong *et al*., 2020).

2.3.7. Rosehip seed oil (*Rosa canina* seed extract)

Rosa species, sometimes known as rose hips, are common wild plants that have long been used as medicinal ingredients to treat a wide range of illnesses. The anti-oxidant properties of these plants, which contain ascorbic acid, phenolic compounds, and healthful fatty acids among others in their phytochemical composition, are what give them their therapeutic potential. Because of recent studies exploring its possible use as a treatment for numerous ailments, including skin disorders, interest in rose hips as a medicine has grown over the past several years. Rosehip seed oil contains components that are mostly advantageous to the healing process. This oil is extracted from the seeds of *Rosa moschata* or *Rosa rubiginosa*, a wild species in the rose family. It is rich in important fatty acids, particularly linoleic acid (41%) and linolenic acid (39%). Additionally, it contains vitamin, retinoic acid, and 16% oleicid. Rosehip seed oil has been tested in a few case series and small exploratory studies for its effectiveness and safety in the prevention and treatment of a number of clinical conditions, including radiotherapy-induced epithelitis, hidradenitis, venous ulcers, proliferative hyperplasia or rapidly evolving tumors, and tumors related to traffic accidents, cryosurgery, or electrosurgery. The results have been positive. Antibacterial effect on pathogenic bacteria *Clostridium perfringens* and *Escherichia coli* was proven (Aguirre-Romero *et al*., 2020).

2.3.8. Horseradish extract (from the root of *Armoracia rusticana*)

Horseradish, *Armoracia rusticana* is an extremely hardy perennial plant, a member of the *Brassicaeae* family. Its root and leaves were used in antiquity both as a medicinal plant and as a spice. Currently, it is cultivated for its thick, fleshy and white roots, which have a mixture of delicious intense pungency and cooling taste, caused by sulfur compounds, namely glucosinolates.

Horseradish is not widely used in the cosmetics industry but is used in the pharmaceutical industry with the following benefits: has antioxidant properties, help to increase the body's immunity and stimulate the activity and production of white blood cells, the body's main line of defense. Contributes to reducing hypertension, stimulating digestion and combating the pathogenic action of bacteria (*Mycobacterium tuberculosis, Helicobacter pilori, Bacillus subtilis, Bacillus pyocianicus, Escherichia coli, Staphylococus sp. Streptococus mutans*, etc.). It has diuretic and stimulating properties of renal function and adrenal glands. Horseradish also has beneficial influences in diseases such as asthma, rheumatism, gout, urinary stones, leukorrhea, heart disease, as well as in maintaining the proper functioning of the gastrointestinal tract. Due to its content in peroxidase, horseradish is an alternative in the treatment of cancer, 1:30 extract in 10:90 (g:g) hydroglyceric solution, horseradish root (*Armoracia rusticana*) being used.

3. Conclusions

Recently, the market for cosmetics and personal care products has been increasingly shifted towards natural ingredients through increasing consumer awareness of personal health and safety and their desire to use safer cosmetics without harmful chemicals. Preservatives are no exception to the evidence or suspicions about the toxicity of certain synthetic products that have existed for decades; this reason alone have pushed the cosmetics industry to seek natural alternatives.

Natural compounds provide extra safety for consumers and can play various roles in a single cosmetic formula, acting as active ingredients (moisturizers), excipients (surfactants), additives (preservatives). The use of natural extracts to control microorganisms in cosmetics is a safe method that gives manufacturers the opportunity to create safe and sustainable products.

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UTILIZAREA EXTRACTELOR NATURALE PENTRU A PREVENI CONTAMINAREA MICROBIANĂ A PRODUSELOR COSMETICE

(Rezumat)

Industria cosmetică mondială s-a dezvoltat mult în ultimul deceniu, iar evoluţia sa continuă să fie determinată în principal de consumatorii care aşteaptă produse din ce în ce mai inovatoare, precum şi de calitate şi eficacitate maximă. Cu toate acestea, creşterea gradului de conștientizare cu privire la sănătatea și siguranța personală i-a determinat pe consumatori să aştepte cu nerăbdare produse cosmetice mai sigure, fără substanțe chimice dăunătoare. Prin urmare, comerțul global cu ingrediente naturale provenite din surse regenerabile vegetale, minerale sau marine este într-o continuă creştere, ceea ce ilustrează perfect această tendință importantă în ultimii ani. Predominanța unor astfel de ingrediente naturale se datorează în mare măsură diverselor roluri pe care le pot juca într-o singură formulă cosmetică, acționând ca ingrediente active (hidratante), excipienți (surfactanți) sau aditivi (conservanți).

Efectul antimicrobian al unor plante și utilizarea lor în produsele cosmetice este cunoscut încă din cele mai vechi timpuri și fac obiectul unei investigații științifice continue. De-a lungul anilor, a devenit disponibilă o înțelegere mai profundă a comportamentului pielii și a plantelor, cu imagini din ce în ce mai complexe. Plantele sunt organisme complexe care produc metaboliți diferiți care răspund mediului în care trăiesc. Aplicate pe piele, extractele din plante și uleiurile esențiale interacționează cu celulele pielii și îmbunătățesc aspectul pielii. Studiile etnobotanice și analizele fizico-chimice au identificat o multitudine de plante cu potențial de a îmbogăți și îmbunătăți produsele cosmetice moderne. În ultimii ani, o serie de studii de laborator au evidenţiat eficiența extractelor de plante şi a produselor fitochimice ca agenţi antimicrobieni. Câteva exemple de clase de materiale vegetale care oferă protecție antimicrobiană includ uleiurile esențiale (uleiul de arbore de ceai, uleiul de rozmarin, uleiul de curcuma, ulei din semințe de măceșe), extractele din plante (extract de rozmarin, extract de salvie, extract de lămâie, extract de ceai verde, extract de *Kaempferia galanga*, extract de frunze de Neem și extract de Hrean).