Substances of natural origin used in the sun protection of the skin

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Abstract

In the period of increased sun exposure, we are exposed to its impact, above all on our skin. Sunlight emits UV radiation, the effect of which is widely recognized as the main factor responsible for the aging of human skin. Preventing the harmful effects of light on the skin is a challenge for the cosmetics and pharmaceutical industries. Research centers are undergoing intensive experiments on the use of natural and synthetic substances in the prevention of adverse dermatological changes. Photoaging of the skin is a process leading to the loss of its firmness and flaccidity, and consequently to the formation of furrows, wrinkles, discolorations and other aesthetic imperfections. Substances obtained, inter alia, from marine algae, lichens, fungi, plants (oils, extracts) and propolis have anti-aging effects in protecting the skin from light. Recent research suggests the protective properties of phenylpropanoids and their glycosylated metabolites, aglycones and glycosylated flavonoids and plant polyphenols. Natural cosmetics have many advantages, thanks to which they are more willingly bought than those that are produced from artificial ingredients. Their main advantage is their origin from the natural environment or organic farming. These substances are rich in valuable minerals and vitamins, they are also safe to use and are most often suitable for use in all types of skin and hair. They are not tested on animals (because they are based on traditional recipes, centuries-long observations and experience), they are characterized by a wide selection of products and their

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availability at competitive prices. The use of cosmetics protecting against the negative effects of sunlight allows you to preserve the aesthetic appearance and color of the skin. The optimal cosmetic effect is obtained by using natural cosmetics, diet, physical activity and an optimistic attitude towards life.

Introduction

The skin is one of the largest organs of the human body, while performing many different physiological functions. Responsible for protecting the body against infections and external factors, including the harmful effects of UV radiation. Ultraviolet radiation is electromagnetic radiation, invisible to humans, one of whose sources is the sun. As a result of absorbing solar radiation by nucleic acids and proteins, physicochemical changes in the cell are induced. Ultraviolet radiation is responsible for early and late skin damage. There is often a change in the color of the skin, which depends primarily on the length of exposure of the human body to the sun, as well as on the thickness and type of skin, the degree of melanin secretion and the intensity of radiation [1]. As a result of excessive exposure to the sun under the influence of external factors, premature aging of the skin called photoaging may occur [2]. Due to the proven properties of using sunscreen cosmetics, they have gained a lot of popularity in recent years. The main advantage of the use of sunscreens is the protection of the human body against harmful UV radiation. The use of both natural and synthetic cosmetics has found application in many areas of skin treatment, improvement of its condition and preventive actions. The word "cosmetics" means "kosmeticos" in Greek, which translates as "adorn". Therefore, nowadays every cosmetic is used as a preparation used to improve or enhance the appearance [3].

This approach to cosmetics contributes to an increasing amount of research into the advantages of these products. This is the reason for the development of more and more modern technologies for their production. Most consumers are mostly interested in cosmetics based on natural ingredients without the use of artificial ingredients [4]. The cosmetics used for sun protection primarily fulfill the protective function against increased sun exposure and include in their scope all skin care products [5]. Currently on the cosmetics market there are many different cosmetics used in sun protection, among others these are oils, creams and balms. The common feature of these preparations is that they must have sunscreens that are responsible for providing adequate protection against harmful UV radiation (UVA and UVB) [6]. Skin is continuously exposed to a variety of environmental stresses, including ultraviolet (UV) radiation. UVB is an inherent component of sunlight that crosses the epidermis and reaches the upper dermis, leading to increased oxidative stress, activation of inflammatory response and accumulation of DNA damage among other effects. The increase in UVB radiation on earth due to the destruction of stratospheric ozone poses a major environmental threat to the skin, increasing the risk of damage with long-term consequences, such as photoaging and photocarcinogenesis [7].

In this review we summarized the most current and relevant information concerning plant extracts and natural compounds that are able to protect or mitigate the deleterious effects caused by sun radiation. This article as well will focus on the effects of selected botanical substances in the prevention of whole harmful ravages of sun.

Skin protection against sunlight

Skin is one of the most UV-sensitive human organs, with a complex, layered structure and performing many important functions. First of all, it protects the body from the outside, thanks to which the body can communicate with the world that surrounds it. Contributes to its proper functioning as a whole, characterized by a fairly large surface area and a significant

degree of anatomical diversity. Due to its wide range of activities, the skin is distinguished by the protection of tissues and internal organs against mechanical, chemical and biological factors. Participates in fatty, hydro-mineral and vitamin management as well as thermoregulation of the body [8]. The skin consists of the epidermis and dermis. Underneath there is subcutaneous tissue, and the elements that form a coherent whole with the skin are its appendages: hair, nails, sweat glands and sebaceous glands. Ultraviolet radiation primarily affects only the surface of the epidermis. It gets damaged, visible as hyperkeratosis and the appearance of a reaction similar to a burn. In addition, excessive sun exposure is mutagenic, carcinogenic and genotoxic, and at the molecular level it is responsible for DNA damage [9].

Consumers usually reach for high-quality cosmetics. Such a choice gives a hint to producers that through the use of a particular cosmetic, you want to get comprehensive protection of the skin against UV radiation, and at the same time prevent skin aging, wrinkle reduction and moisturizing. Therefore, manufacturers should take into account the positive effects of substances of natural origin used in the cosmetics industry to protect and prevent sunscreen. They should know the effects of natural substances that have moisturizing and cooling properties and provide adequate skin tone [10]. Nowadays, the incidence of skin cancers is increasing, therefore it is recommended to use cosmetics to protect against the harmful effects of the sun with a wide range of use. Substances of natural origin primarily act as absorbing UV rays and are most often used to minimize the use of chemical filters found in cosmetics for skin care. Natural ingredients are characterized by a wide spectrum of applications including: antioxidant, anti-inflammatory, immunoducing and protective. However, natural substances and plant extracts have a low sun protection factor (SPF) so that they can be used alone in cosmetics used for tanning, compared to other filters, e.g. chemical ones. However, due to the multitude of positive properties, they can be a source of valuable ingredients used in the production of creams with low SPF, which can be used for daily skin care [11]. Natural sunscreens have a beneficial effect of the skin. Natural antioxidants due to their properties are desirable ingredients in cosmetic preparations. UV filters are more often used in the production of cosmetics for everyday use, for the body as well as for hair [12]. Substances of natural origin primarily contain a significant amount of active substances, hat have a positive effect on our skin. The main advantages are: counteracting the late effects of UV radiation (carcinogenesis, skin aging) [13]. Ultraviolet radiation is harmful to the skin, causing damage. As a result of exposure to the sun, reactive oxygen forms. However, taking into account the various uses of natural origin substances, there are many options to counteract the negative effects of ultraviolet radiation. An example here may be phytochemical compounds, above all phenols and flavonoids [14].

Potentials of the natural substances in to sun protection cosmetics

The substances of natural origin used in the production of cosmetics as a means of preventing harmful effects of sunlight on the skin are primarily proteins (peptide bonds), which are designed to absorb lipids and nucleotides. The purpose of vegetable proteins in cosmetics is to protect the bonds inside skin proteins. Therefore, the higher the level of vegetable proteins, the greater the protection of said bonds. On the other hand, the high level of squalane, mainly obtained from olive oil and used in some cosmetic products, is the protective function of sensitive skin lipids. Due to its properties allantoin, as a nucleotide that occurs naturally in the body and is responsible for absorbing the spectrum of UV radiation. Solar radiation contributes to damage to the cell's DNA, whereas allantoin is used for the production of tanning and post-tanning cosmetics as an adjuvant for increased skin exposure to the sun due to its curative, anti-inflammatory and soothing properties. Allantoin is a plant extract obtained from comfrey (*Symphytum officinale* L.) [15,16]. Proanthocyanidin in the form of a cream shows effectiveness against dangerous consequences of sunlight. The effect of the applied

cosmetic product containing oligomeric grape seed proantocyanides (OPC) before sun-tanning is to reduce the burning of the skin at the time of sun exposure [17]. Oil extracted from sea buckthorn fruit and flesh (*Hippophae rhamnoides*) has long been recognized as a component of proper skin care especially in Turkey, China and Russia [14]. Aloe vera (*Aloe vera*) is used in the production of cosmetics due to its soothing and cooling properties. The beneficial effect of aloe has been scientifically proven in terms of the healing properties of various types of burns, including thermal and solar [18]. Properties protecting against the harmful effects of UV rays on the skin are shown by extracts from: inflorescence of edorsement *(Helichrysi inflorescentia),* chamomile basketsand *(Chamomillae anthodium)* e.g. the root of the Baikal thyroid *(Scutellariae rhizoma et radix)* [19]. It is also worth mentioning the beneficial effects of chocolate, because it contains significant amounts of antioxidants. consuming it serves a natural protective mechanism, providing protection against the side effects of sunbathin [20]. Scientifically it has been shown that cocoa contains a large amount of flavonoids, thanks to which chocolate has photoprotective properties and consumption of it will improve the structure and circulation of the skin [21].

The use of flavones as ingredients of preparations used to protect the sun's skin against UV radiation may be based on the effects of substances found in many edible and medicinal plants [22,23]. An example may be quercetin, found in the skin of onions [24]

Research shows that the antioxidant properties of vitamin E (α-tocopherol) can be used in the production of natural cosmetics to protect the skin from damage caused by exposure to the sun [25]. It has been proven that the topical use of preparations containing antioxidants leads to the reduction of acute and chronic photodegradation damages [26]. A very important protective role for the skin is made up of vegetable oils containing mainly vitamin E. These include, for example, wheat germ oil (*Triticum vulgare*), sunflower (*Helianthus annuus*), sesame (*Sesamum indicum*), hazelnut (*Corylus avellana*) and pumpkin seeds (*Cucurbita pepo*). These oils nourish and prevent the loss of moisture from the skin and have excellent antioxidant properties [14]. Another vitamin important because of its properties is vitamin C (L-*ascorbic acid*). It is the most important intra- and extracellular antioxidant in the aqueous phase. Vitamin C provides many benefits for the proper functioning of the skin, mainly increasing the synthesis of collagen and photoprotection [27]. Vitamin C in terms of antioxidant properties is up to 200 times more effective than vitamin E. In addition it has a possitive effect on the epidermal barrier. Its positive properties can be seen in the example of local application of L- ascorbicacid, which has protective properties against damage caused by excessive sun exposure (erythema, sunburn) [28].

Tea plant (*Camellia sinensis*) also plays a very important role in protecting against sun exposure. Due to the tea ingredients, tannin and theobromine are commonly used as a home remedy for sunburn. In contrast, other compounds contained in tea (catechins), act curative and preventive damage to the skin, and even help to prevent skin cancer resulting from excessive radiation [29]. Scientific research has proven that complex polyphenolic compounds contained in green tea mitigate adverse effects after excessive exposure to the sun. The main ingredient of green tea, epigallocatechin gallate is used in many cosmetics as an anti-inflammatory, antioxidant and for better tanning [30]. As a result of scientific research, the Chinese lemon *(Schisandra chinensis*) extract has been proven to have a positive effect on UV radiation. It abounds in polyphenols, thanks to which it has melanogenesis-inhibiting properties. Therefore, it should be taken into account in the production of protective cosmetic preparations [31]. It has been scientifically proven that some vegetable oils contain natural sunscreens that protect the skin against the dissolution of sebum, thus contributing to evaporation from the skin [32]. You can mention here, for example, borage/ starflower oil (*Borago officinali*), stimulating the activity of skin cells and leading to its regeneration [33], evening-primrose oil (*Oenothera biennis*) is responsible for restoring skin health, avocado oil (*Persea americana*) soothes and protects skin, as well as tea tree oil (*Melaleuca alternifolia*)- a popular ingredient in many sunscreen preparations that soothes sunburn and increases blood flow in the capillaries of the skin [32]. It is worth paying

attentionto to the properties of other vegetable fats such as: macademia oil, jojoba oil, shea butter and argan oil. They show vow performance with respect to protective action however, they are responsible for a wide range of ultraviolet radation absorption. Tests of the abovementioned oils were carried out by electron resonance spectroscopy pay attention on a wide scale and various antiradical effects of the tested substances [34]. The use of raspberry seed oil is growing in interest in the production of natural cosmetics. Raspberry oil is responsible for more effective regeneration of the epidermis, soothing irritations resulting from excessive sun exposure. First of all, raspberry oil is a source of vitamin A, which promotes faster regeneration of damaged epidermis and the development of new cells in comparison with the properties of other natural oils [35]. Raspberry fruit has many positive properties. Is responsible for the absorption of ultraviolet rays (UV-B, UV-C), as well as soothes any skin irritation. Raspberry oil contains such compounds as tocophenols and carotenoids. The main advantage of these compounds is protection against damage, including proteins and lipids, and genetic material. Due to the above properties, raspberry oil can become a substance used in the production of sun protection cosmetics on a large scale in a short time [36]. Due to the positive properties of pomegranate seed oil, it is worth mentioning its role in the composition of cosmetics for sunburn. Pomegranate seed oil is a wealth of phytosterols, phytoestrogens as well as polyphenols. In connection with the presence of flavonoids and punic acid, it has been used in the production of cosmetics protecting against excessive sun exposure [37].

Prevention of skin photoaging

Solar broadband UV irradiation is commonly regarded as a major causative reason for cutaneous photoaging. The proaging molecular pathways and cellular targets affected by UVA+UVB light in human skin have been extensively investigated. Notwithstanding growing knowledge in mechanisms of photoaging, research and development of clinically efficient, nontoxic, and sustainable topical preparations providing full physical, chemical, and biological photoprotection still remain a great challenge for pharmaceutical and cosmetic industries [38]. Protective properties of secondary plant metabolites against solar light of broad spectral range from UV irradiation to visible and infrared light [39] are greatly similar for plant and mammalian cells. This possibility of universal defense is provided by peculiar chemical structure (chromophores) that allows to absorb solar light energy and dissipate it either in the form of thermal or fluorescent/phosphorescent light energy (sunscreen properties) or convert it into energy for chemical reactions (photosensitizing properties). In this study, we preselected plant polyphenols, mainly with phenylpropanoid, flavonoid, stilbene, and catechin chemical structures, based on several grounds: 1) biosynthesis of these secondary metabolites through phenylpropanoid pathway is rapidly upregulated in plants/plant cells upon exposure to solar irradiation [39, 40]; 2) plant/plant cell protection against damage related to solar UV irradiation is correlated with enhanced levels of phenylpropanoids, their glycosylated derivatives, and flavonoids [41]; and 3) chemical structures of preselected secondary metabolites are not nitrogen-containing heterocycles, which mostly belong to photosensitizers hence promote type I or II photochemical reactions. The great majority of preselected plant polyphenols were much more or equally effective in UVB screening as benzophenone-3, a golden standard for providing an SPF-B protection. A few of them, catechin, in particular, did not effectively absorb UVB [42].

Skin photoaging is a consequence of the oxidative stress generated upon exposure to UV radiation. However, the skin is normally protected from the negative effects of oxidative stress by endogenous antioxidant systems, which, unfortunately, undergo a progressive decline during aging. Several lines of evidence support the hypothesis that secondary metabolites from plants act as natural antioxidants able to decrease or retard the development and progression of life style-related diseases. The intake of dietary antioxidants plays a fundamental role in the protection against oxidative injury; therefore, a correct diet is crucial to extend lifespan. Accordingly, several *in vitro*, *in vivo*,

and human intervention studies demonstrated that antioxidants deriving from natural products, most of them assumed with the Mediterranean diet, are particularly effective in the protection of skin from photoaging [43]. Indeed, a regular intake of vitamins, polyunsaturated fatty acids, and polyphenols from plant sources has been shown to contribute to the prevention of age-related diseases. The search for effective natural compounds able to protect against the deleterious effects of photoaging has been intensified in recent years. The list of molecules with antiaging potential extracted from different parts of a number of plant species is continuously growing [44].

UV radiation cause skin damages. Everybody needs protection from harmful UV lights. There are many different ways to protect our skin. The best way is avoiding direct sun exposure. But sometimes, it can be impossible, especially during summer. Because of that, sunscreen products should be used. Consumers request high-quality products with accessible prizes. It means that they want to get everything when they apply these products. All in one: Protection skin from UV radiation, antiaging and wrinkles reduction, moisturizing and cooling effects on the skin without allergic reaction, and coloring effects on the skin. This request is the main guide for scientists and researchers. Also, they know that chemical components sometimes have harmful effects on the skin. Because of that, they more and more choose products with natural components. Using natural ingredients in different skin care products is very popular today. Plants' ability to protect themselves from UV radiation from the sun is the main reason for that. Plants have a good potential to help us. Plant phenolics are one candidate for prevention of harmful effects of UV radiation on the skin. Additionally, plants contain a lot of other substances which can be useful for skin care. Their potential is still undefined. Nevertheless, more research trials and clinical evidences are needed [45]. For example, extracts from the red algae *P. umbilicalis* could be considered effective ingredients to be used in sunscreen formulations. The combination of vitamins A, E, C and *G. biloba* along with red algae extracts can improve significantly the performance of the sunscreens, preventing UV-induced DNA damage and inflammation. Thus, they should be considered an interesting combination for an effective photoprotective formulation with antiaging properties [46]. Many species of marine algae have been used as extracts in cosmetics, and there is no restriction for cosmetic use. Hence, marine algae may be considered a consumer-friendly source of skin care and cosmetic products that may be used for photoprotection. However, the health claims of photoprotective substances derived from marine algae that have been reported by many studies are mostly acquired only through *in vitro* and *in vivo* studies, so comprehensive studies on the mode of photoprotective action, biological consequences, and possible side effects have to be conducted in order to use those functional materials as skin care and cosmetic products. Photoprotective activity of orally administered bioactive substances from marine algae has also been reported [47]. Several natural compounds with UV absorption property have been used to substitute for or to reduce the quantity of synthetic sunscreen agents. In addition to UV absorption property, most natural compounds were found to act as antioxidants, anti-inflammatory, and immunomodulatory agents, which provide further protection against the damaging effects of UV radiation exposure. Compounds derived from natural sources have gained considerable attention for use in sunscreen products and have bolstered the market trend toward natural cosmetics [48]. Exposure of skin to sunlight and other atmospheric conditions causes the production of reactive oxygen species, which can react with DNA, proteins, and fatty acids, causing oxidative damage and impairment of antioxidant system. Such injuries damage regulation pathways of skin and lead to photoaging and skin cancer development. The effects of aging include wrinkles, roughness, appearance of fine lines, lack of elasticity, and de- or hyperpigmentation marks. Herbal extracts act on these areas and produce healing, softening, rejuvenating, and sunscreen effects. We have selected a few photoprotective phytoconstituents, such as curcumin, resveratrol, tea polyphenols, silymarin, quercetin and ascorbic acid, and have discussed the considerations to be undertaken for the development of herbal cosmetic formulations that could reduce the occurrence of skin cancer and delay the process of photoaging [49].

Summary

Substances derived from natural sources have recently become particularly important when used in products for prevention and protection against harmful effects of solar radiation on the skin. Thus, they strengthened the demand for the natural cosmetics market, and this has increased the importance of the wide range of properties that natural substances used to manufacture cosmetics have to offer. In order to ensure the effectiveness of sunscreen products, the most important are the amount of active ingredients in natural extracts, compatibility, and the concentration of ingredients found in natural substances [49]. Each of us should be aware of the positive and negative effects of sunbathing. The benefits of exposure to sunlight are definitely a positive effect on the skeletal, cardiovascular and immune systems. Negative effects may include burns, keratinization, reduced elasticity and skin cancer. In order to prevent the harmful effects of exposure to UV radiation, protective cosmetics are used and that is why it is very important that these preparations are used only natural ingredients whose use does not pose a threat to our health [50]. Plant extracts and natural compounds are traditionally used in the treatment of skin diseases as well as in rejuvenating and photoprotective cosmetic formulations. The growing demand in the consumer market for natural cosmetics justifies the evaluation of the bioactive properties and the efficacy of these natural products in combating the damaging effects caused by sunlight [7]. Verbascoside and leontopodic acids produced by plant cell cultures elicited by UV are promising anti-photoaging actives. The entirely "natural" approach to prevent photoaging and UV-related skin pathologies could diminish negative impact of synthetic sunscreens toward human health and environment [38]. The development of novel preventive and therapeutic strategies depends on our understanding of the molecular mechanism of UV-damage. The newest trend will be to stay continuously cool, while remaining in the sun. Cooling is achieved through evaporating water, alcohol, or any other low-density vapor-producing solvents or materials that leave a cooling effect on the skin. Thanks to the encapsulating technology that can deliver water or other cooling agents with intermittent release through a rub mechanism [51]. More recent changes in lifestyle have led to a significant increase in the amount of UV-B radiation people receive leading to a surge in the incidence of skin cancer and photoaging. As these trends are likely to continue in the foreseeable future, the adverse effect of UV-B has become a major human health concern. Therefore, development of novel strategies to reduce the occurrence of skin cancer and delay the process of photoaging are highly desirable goals. One approach to reduce their occurrence is through photochemoprevention, which we define as the use of agents capable of ameliorating the adverse effects of UV-B on the skin. Photochemoprevention via use of botanical antioxidants, present in the common diet of human have gained considerable attention as photochemopreventive agents for human us [52].

Skin protection against sun is vitally important at any age. Prolonged exposure to the sun's radiation apart adequate protection can increase the risk of contracting serious skin conditions, photoaging, water loss, including cancer. Plants thrive in direct sunlight and high heat, so their extracts protect us from the sun's radiation. Nature several plant extracts are not classified as sunscreens but which can boost the sun protection and keep our skin even safer while exposed to the sunlight. We recommended use for skin sun prevention plants substances which are from natural sources.

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