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Review

Herbal extracts, lichens and biomolecules as natural photo-protection alternatives to synthetic UV filters. A systematic review

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ABSTRACT

Besides the unquestionable positive effects of solar exposure for human health, UV rays have been widely investigated for toxicology aspects related to excessive UVB and UVA doses, which involve sunburns, skin aging, DNA skin damage and tumorigenesis. At present, synthetic and mineral sunscreens are used to protect against these damages but several natural molecules can provide UV protection, including also synergic effect or enhanced photo stability. Although a large number of herbal extracts and plant origin molecules can deserve potential applications, most of the study reported utilizes different method and different strategies of investigation, making thus difficult to understand the real versus claimed potential. This is possibly one of the reasons why, beside the large body of literature there are no officially approved natural commercial sun-filter but a consistent number of commercially available solar products (sunscreen) on the market that contain herbal derivatives. In this review we have evaluated the papers appeared in the last 15 years and we have critically collected the most significant data. Several databases, namely Scifinder, Pubmed, Google Scholar, ISI-Web of Science and Scopus, were used as literature sources; excluding patents and symposium or congress papers. Only articles in the English language have been selected. New formulation, new skin delivery systems, skin penetration enhancers and boosters are most likely the next frontier of investigation in order to better understand the role of whole herbal extracts in exerting their photo protective activity.

Contents

Abbreviations: BCC, basal cell melanoma; CoQ_{10}, coenzyme Q_{10}; CPDs, cyclobutane pyrimidine dimers; COX-2, cyclooxygenase-2; DDE, D. Don herbal extract; GSH, endogenous reduced glutathione; EGCG, epigallocathetin gallate; GAE, gallic acid and ethyl gallate; GTP, green tea polyphenols; NHDF, human dermal fibroblast cells; iNOS, inducible nitric oxide synthase; IRA, infrared A radiation; MMPs, matrix metalloproteinases; MPF, membrane protection factor; MED, minimal erythemal dose; NLCs, nanostructured lipid carriers; NO, nitric oxide; NMSC, non-melanoma skin cancer; OMC, octylmethoxycinnamate; PPD, persistent pigment darkening; ROS, reactive oxygen species; SCC, squamous cell carcinoma; SPF, sun protection factor; TCA, trans-communic acid; TNF-α, tumor necrosis factor-α.

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1. Introduction

The sun is life for living beings and earth; oxygen, water and food cycles are connected with UV radiation. Regarding human health, most of the positive effects of solar radiations are mediated by UVB production of vitamin D in skin. However, several other effects may be considered: tanning (increases melanin in skin as sunscreen) and improvement of psoriasis, vitiligo, atopic dermatitis and localized scleroderma by heliotherapy or phototherapy (artificial UV radiation). Furthermore, reductions of blood pressure and antimicrobial effects have been attributed to UV-induced nitric oxide (NO) production, which can also act as a neurotransmitter. Finally, UV exposure may improve mood through the release of endorphins. All these effects have been extensively reviewed in recent works. Keratinocytes produce opioid Beta-endorphin following UV exposure and this effect may be implicated in tanning 'addiction'. Sun exposure is associated with improved mood and increased energy levels. Melatonin and serotonin regulation is influenced by sunlight, and improvement in cognition is observed with increased sun exposure particularly in depressed individuals [1,2].

However, UV light is included in the Tenth Report on Carcinogens from the National Institute of Environmental Health Sciences, and UV radiation is deemed as the main etiological agent of a large number of skin cancers, sunburns and oxidative stress. In a recent study, Valachovic and Zurbenko [3] highlighted that skin cancer has been diagnosed in >2 million individuals, every year, in the United States. Chronic exposure of human skin to solar UV radiation is widely recognised as the key factor responsible for photoaging. For these reasons the role of photoprotection is critical to avoid skin cancer and others undesired effects [4].

The natural products are reasonably likely to be the future of cosmetics, and this trend necessarily involves solar products and specifically the UV filters. So if the current trend is to seek the naturalness and sustainability, you must always communicate with greater transparency the structure of supply chains, the origin of cosmetic raw materials and the ecological footprint that can leave. The efforts in research and innovation are directed to set new sustainability protocols, geared mainly to organic certification, with the aim of ensuring the final consumer about the safety, the ethic and sustainability of the product [5].

Finally, one should consider the sun protection as a complex issue, based on mixed factors, including oral and topical applications, physical blockers and chemical filters, boosters (i.e. antioxidant) clothing and glasses [4].

This review summarizes current topics in the research of natural UV filters, with special emphasis on photoprotective properties of different molecules from natural origin or their antioxidant and repairing mechanisms. List of different plants containing several organic molecules have been discussed in this review with respect to their photo-protective activity via different mechanism and represented in Tables 1 and 2. The same approach has been applied to lichens extracts, as reported in Table 3. Table 4 summarize additional studies regarding pure molecules that have been investigated for their photo protection capability.

2. Materials and methods

The present systematic review was performed adopting the following electronic databases: Scifinder, Pubmed, Google Scholar, ISI-Web of Science and Scopus. Three reviewers extracted data independently and the final papers selection were completed avoiding duplication of data. Systematic searching includes articles from the past 15 years; moreover, we also considered some key papers from 1974 to 2015, for the first three chapters (introduction, materials and methods, skin care mechanism). Selection criteria were defined including only natural herbal extracts, lichens extracts and pure molecules available from plant sources, in according with green trends of cosmetic markets. We decided to exceptionally include some enzymes, available by biotechnology process. Animal raw materials have been considerate an exclusion criterion for the data included in the present review.

The following keywords were selected: sunscreen, SPF or Sun Protection Factor, plant oils, UV filter, natural UV filter. All key words were searched individually and in combination. Only articles in the English language have been selected and were excluded data from patents, symposiums and congress abstracts; these latter because not enough complete to warrant an effective comparison with full papers. As described in Fig. 1, the above mentioned criteria allowed selecting 103 eligible articles, excluding 10 papers which did not satisfied the selection methodology. Rejected papers did not show a clearly botanical identification.

3. Skin care mechanisms

3.1. UV toxicology

In Australia it has been reported the highest incidence of non-melanoma skin cancer (NMSC), including basal cell melanoma (BCC) and squamous cell carcinoma (SCC). A recent review analysed 21 Australians studies that investigated the incidence of NMSC. The result per 100,000 person-years was estimated to be 555 in 1985; 977 in 1990; 1109 in 1995; 1170 in 2002 and 2448 in 2011, indicating probably an increasing health problem. Incidence varied across the country with the highest value in Queensland. The prevalence of NMSC was estimated to be 2% in Australia in 2002 [6].

Regarding UV protection, epithelial skin cancer and the role of UV protection in melanoma prevention, there are substantial evidence that UV protection is important in order to reduce the risk of squamous cell carcinoma, actinic keratosis and probably also the risk of melanoma [7].

A recent study about sunlight-induced melanoma can arise from cyclobutane pyrimidine dimers (CPDs) generated into the melanocytes and CPDs are generated for >3 h after exposure to UVA. This study confirms that the chemical excitation of melanin derivatives induces DNA photoproducts long after UV [8].

Furthermore, the pattern is complicated by synergic potentiation of UV rays by chemical environment and by the altitude at which the irradiation occurs, sometimes with unpredictable effects [3,9].