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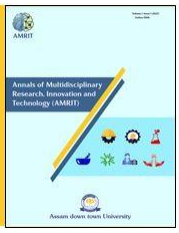

REVIEW ARTICLE

HERBAL PLANTS IN SKIN PROTECTION

Potential of Herbal Plants in Skin Protection from Aging and Ultraviolet Radiation

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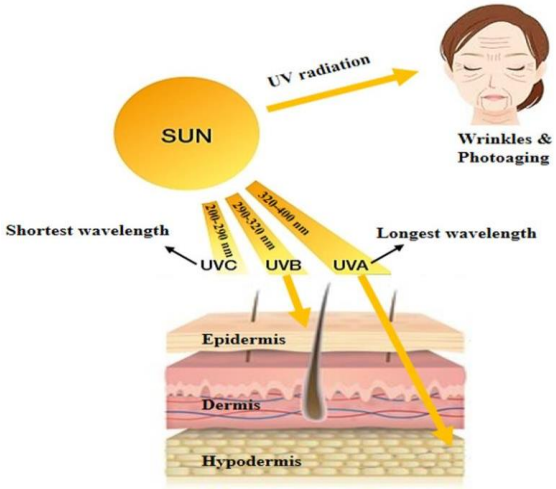
Abstract

Herbal preparations have been used in medicines and cosmetics over the past few decades. As ultraviolet (UV) radiation can cause sunburns, wrinkles, dark spot, premature aging, and cancer so, it is essential to protect the skin from UV radiation and prevent from their side effects. Moreover, as skin is the most visible organ so it makes us more cautious to maintain a flawless, glowing, smooth healthy skin. Herbal products are already gaining attention in order to protect the skin from aging and sunburns with no serious side effects. Previous studies have stated that many herbal ingredients impart their photo-protective effects through the regulation of UV-induced skin inflammation, antioxidant effects and aging. Additionally, natural components can inhibit free radical formation and neutralize reactive oxygen species and enhance skin protection from UV rays. Therefore, traditional use of herbs in medication or beautification is the basis for researches and making new trends in cosmetics by providing effective and cost-efficient skin care products which would be of great benefit to the society. This review focuses on several active constituents responsible for photo protection, types of UV radiations, damaging effects of UV radiation, and study of different active constituents present in various herbal plants responsible for UV protecting effect.

Keywords: *Herbal plants, Photo-ageing, Skin damage, Sunscreens, Ultraviolet radiation*

Graphical abstract:



1 Introduction

Skin is a pliable, self-mending cover that differentiates the body's internal environment from that of the external environment. The proliferating layer of the skin is the epidermis. It takes about 56 to 72 days for our skin to renew itself and is called epidermal turnover time. The duration for this is increased during aging as there is a decline in cell metabolism and mitotic rates. The state of subtle decrease in the body's ability to do things and metabolic activities after reaching a stage of maturity is known as aging. The process of aging is classified into (i) Intrinsic aging which is a sequential and inescapable life event, and (ii) Actinic aging which is based on a person's vulnerability to UV radiation [1].

There is a growing interest in the protection of the skin from the aging process, light, and radiation necessitating to exploration of novel, efficacious, and safer dermatological preparations containing active ingredients with many effective uses. Plants are known to be a possible source of biologically active material that is used in the therapy of different skin infections [2]. Various agents and active cosmetic ingredients with proven health benefits like anti-aging, antioxidant, anti-inflammatory, UV- protection, anti-cancer, anti-wrinkle, skin smoothing, skin whitening, and moisturizing are being developed using plant-based resources [3]. Natural ingredients are considered safer in comparison to synthetic ingredients in dermatological and cosmetic product preparations. Plants are known to produce natural antioxidants that help control oxidative stress [2]. The demand for high-quality natural products that are both efficient and beneficial is ever-growing in the cosmeceutical industry [3]. The present review has been made to examine the antioxidant, anti-aging, and UV radiation protecting activity of different herbal ingredients in the form of pharmaceutical preparations.

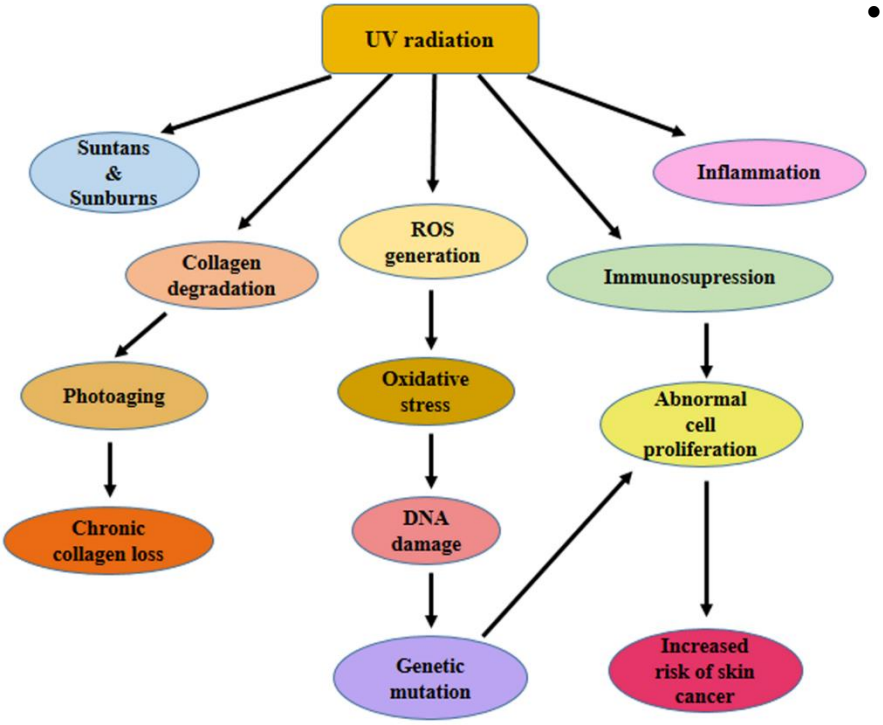
1.1 Skin Aging and Skin Damage from UV Radiation

Traditional medicines of plant origin are popularly used in China, Japan, Thailand, India, Sri Lanka, Pakistan etc. In the developing countries, the medicinal plants continue to play a dominant role in the healthcare system. Herbal medicine has been continuously used and has a long history of use in these countries. Today both industrialized and developing countries are working towards the development and recognition of different drugs produced using medicinal plant extracts. Research is in progress for exploring the newer sources of plant origin and extracts with active principles having highly effective and potentiality although some of the ascribed beneficial properties are inaccurate due to the various tests performed [4]. Nevertheless, new benefits and accuracy to treat different diseases using plant-based products have been found.

1.1.1 Skin ageing

The major probability factor for several life-threatening diseases is aging. The progressive and deleterious changes in the whole organisms due to the interaction of multiple genetic and environmental factors that are caused by the complex molecular process which is steered by the diverse molecular pathways and biochemical events is aging [5]. For the protection of the skin from the external agents which can disrupt the skin and damage its topical skincare products are eligible candidates for the treatment [6]. The process of aging is most evident in the skin as it is the most superficial organ and can be noticed easily. In the skin, there are two types of changes. One of the changes includes aging due to the transit of time alone and is called chronological aging; the next is the term photo-aging which implies the alteration arising from chronic sun exposure [7].

i.e., from 10am to 4pm the UV radiation is the strongest. The UV radiation or UV spectrum that reaches the earth's surface during a summer day consists of UVB at 3.5% and



1.1.2 UV radiation and sunscreens

The advantage of use of sunscreen products is to get appealing sun tan skin effortlessly and quickly without the possibility of getting burns. However, it is imperative to use sunscreen products because of their ability to protect the skin against ultraviolet (UV) radiation. In order of increasing energy and decreasing wavelength, the UV radiation is divided into three distinct bands, UVA (320-400 nm), UVB (290-320 nm), and UVC (200-290 nm). The different wavelengths and energy that are linked to the different UV subclass correlate with the distinctly different outcomes on living tissue. These are:

- **Ultraviolet C radiation or UVC-** The highest energy is possessed by the UVC, and it also has the most potential for biological damage, but the ozone layer successfully filters the UVC radiation and for that reason it is not considered of any biological relevance as it is not an element in solar exposure of human beings as it does not reach the earth's surface.
- **Ultraviolet B radiation UVB -** The UV radiation that reaches the surface of the earth is UVB and UVA but the amount that reaches the surface greatly varies due to the earth's altitude, latitude, season, cloudiness, time of the day, and the most important ozone layer. The equator and the higher elevated places have higher irradiance compared to other places. The ratio at which the UVA to UVB reaches the earth's surface is 20:1. During the day UVA at 96.5%. Erythema and sunburn are primarily associated with UVB. Immunosuppression and photo carcinogenesis can be caused by the UVB radiation [8].
- **Ultraviolet A radiation or UVA-** UVA is rarely affected by the atmospheric condition or altitude as it is of longer wavelength compared with that of UVB. It can infiltrate deeper into the skin in comparison to UVB [9,10] and cannot be filtered through the window panes. Approximately about 50% of the UV exposure takes place in the shaded areas [9,11]. It is seen that the efficiency of UVA is in the induction of delayed tanning and in immediate and delayed pigment darkening, than in causing erythema which is caused by UVB. Adverse effects like immune-suppression, photo-aging, skin cancer and ocular damage are related to the UVA radiation [12]. Vitamin D_3 produced through the irradiation of 7-dihydrocholesterol is the benefit of UVA rays. UVA radiation have been revealed to be the responsible factor for photosensitivity resulting in various types of actinic lesions and allergic reactions [8].

1.1.3 Effects of ultraviolet radiation

UVB irradiation that leads to acute response in human skin includes pigment darkening, edema and erythema, which is then followed by delayed tanning, thickening of the epidermis

and dermis, and synthesis of vitamin D; UVB irradiation that leads to chronic UVB effects are photo-aging, immunosuppression, and photo carcinogenesis (Figure 1) [10]. The erythema which is induced by UVB occurs nearly 4 hours after the exposure and it then peaks at around 8-24 hours, and fades over a day or so; in fair-skinned and older individuals, UVB erythema may be persistent, sometimes lasting for weeks [10,13].

As the wavelength of UVB is shorter than the UVA, the efficacy of UVA to cause erythema is reduced rapidly; for the same erythemal response to occur, it is approximately about 1000 times greater than the UVA dose in comparison to that of UVB [10,14,15]. At the end of an irradiation period, erythema is often noticed immediately [10,16] and fades away in several hours, followed by a delayed erythema starting at about 6 hours and then reaching its peak at 24 hours [10,14]. The UV induced tanning and the action spectrum for erythema are almost similar but, UVA is more efficient in inducing tanning, and erythema is induced well with UVB [10,17]. UV protection besides the reduction and suppression of the harmful effects of the UV radiation totally, are the main function of the Skin care products [18]. So, UV protection has become a major function for many different types of cosmetic formulations.

2 Different Herbal Plants Used as Potential Agents for Anti-Ageing and Sun Protection

Turmeric rhizome (*Curcuma longa*) is used for the extraction of Curcumin; seeds of grape (*V. vinfera*) which contains the chemical Proanthocyanidins [19]. There are many species of plants which includes peanuts, grapes, red wine, fruits and mulberries have a chemical extract in common known as Resveratrol, a polyphenol and a nontoxic botanical-derived flavonoid occurring in numerous fruits, herbs, and vegetables known as Apigenin, possessing the capacity to shield the skin surface from detrimental consequences which is caused by the UV radiation by displaying anti-mutagen, antioxidant, free radical scavenging, anti- inflammatory, and anti-carcinogenic properties [20].

2.1 Ash Gourd

Benincasa hispida (Thunb.) Cogn. or ash gourd, which belongs to the *Cucurbitaceae* family, is used in the Ayurvedic system of medicine. The old, ripened fruit from the plants is used to prepare the medication, and the major constituents of this fruit are glycosides, carotenes, uronic acid, triterpenoids, saccharides, flavanoids, vitamins, and β sitosterin. This medicinal plant is used for different affliction such as heart disease, burning sensation, dyspepsia, diuretic activity, vermifuge, diabetes, anti-inflammatory activity and as an anticancer agent. A study carried out for the formulation of cream [1] and evaluation of the *Benincasa hispida* fruit for its anti-ageing potential showed that it has good skin renewal activity. The study concluded that the prepared cream of Benincasa fruit extract showed to have a significant and better anti-ageing efficiency in comparison to that of the control.

2.2 Fireweed

Epilobium angustifolium L. Holub, belongs to the family Onagraceae, and has been used for several years to treat skin diseases, inflammation, gastrointestinal tract disorders, etc. Moreover, *E. angustifolium* acts as a potential cosmetic ingredient with anti-aging properties which has been confirmed by the cytoprotective effect on the skin cells, fibroblasts, and also keratinocytes [21]. Gallic acid (GA), 3,4-dihydroxybenzoic acid (3,4-DHB), Chlorogenic acid (ChA), 4-hydroxybenzoic acid (4-HB), or caffeic acid (CA) are the active constituents of *E. angustifolium* and it owes its pharmacological effect to it, and the preparation of fireweed are used on the mucous membranes and on the skin surface due to its primary antioxidant activity. As per previous studies [2], the antioxidant, anti-aging, and anti-inflammatory activity of the ethanolic extract from *E. angustifolium*, was examined, and also the perforation ability, from the emulsion and hydrogel of the selected phenolic acids, often used in cosmetology or dermatology. As the compounds of natural genesis are currently in demand and are sought to replace the synthetic substances for the preparation of skincare products and also to treat numerous skin diseases, the vehicles, i.e., the hydrogel and emulsion, which contain the tested extract prepared. In the test performed, the penetration of the extract and their accumulation in the skin were observed and it was found that the phenolic acids contained in the hydrogel penetrated much better compared to the emulsion [22]. This result obtained indicated the possibility of using *E. angustifolium* as an active ingredient, in pharmaceutics and cosmetics when applied to the skin, due to its anti-aging and anti-inflammatory activity gives better results [2].

2.3 Coffee Plant

The extract of the fruits of the coffee plant (*Coffea arabica*), family Rubiaceae acts as a potent antioxidant polyphenol, chiefly Chlorogenic acid, Ferulic acid, Quinic acid and condensed proanthocyanidins, which has been shown to manifest antioxidant activity. The extract of *Coffea arabica*, diminished irritation that then causes photo- aging which is induced by UVB radiation, the usage of the *Coffea arabica* excerpt showed that it repairs or makes pigmentation, wrinkles, fine lines, and the overall appearance of the person better [7].

2.4 Licorice

Glycyrrhiza glabra L or the ethanolic extract of Licorice has shown potent antioxidant pursuit utilizing considerable hydrogen-donating, ROS scavenging, metal ion chelating, mitochondrial antilipid peroxidative and reducing abilities; these consequences were accredited to the soaring content of the phenolic constituent [23]. The main constituent of *G. glabra* is Glycyrrhizin, a combination of two molecules of Glucuronic acid and one molecule of Glycyrrhetinic acid [24]. It is one of the most common medicines used in the Asiatic folk medicines which has the function of an anti-inflammatory agent on neutrophil functions

including ROS generation [24]. Thus, Glycyrrhizin can be contemplated as a blocking agent of lipid peroxidation chain reactions and a quenching agent of free radicals. When tested on animal models, the Glycyrrhizin extract showed an effective anti-oxidant, chemo-preventive, and anti-proliferative activity.

2.5 Poplar bud

The Poplar bud or *Populas nigra* extract have the potential benefits on the ageing skin as it had manifested a strong modulation of transcription of genes involved in antioxidant defenses, inflammatory responses and cell renewal [25].

2.6 Green Tea

Green Tea or the dried buds and leaves of *Camellia sinensis* showed that oral consumption and topical administration of this plant protects the skin against inflammation, chemicals, and also the UV- induced carcinogenesis. In addition to that green tea also prevents the UV-induced immune suppression [7].

2.7 Milk Thistle

The seed of Milk thistle, *Silybum marianum* is used to isolate Silymarin, a flavonoid complex which has shown to have anti-inflammatory, anti-oxidative, and anti-carcinogenic properties in *in-vivo studies* in animal models. Research [26] also shows that Silymarin may positively amplify the protection provided by sunscreen and also provide an additional anti-photo-carcinogenic protection.

2.8 Pomegranate

The extract obtained from Pomegranate, *Punica granatum* may be used as a supplement in skin care products as it has been noticed that the extract can protect the human immortalized HaCaT keratinocytes against UVB-induced oxidative stress and the markers of photo ageing [27]. It was also seen that Catechin, an active component of Pomegranate, also held back the UVB-induced skin photo ageing [28].

2.9 Soybean

Soybean cake is used for the extraction of the Isoflavone which is considered as a quality option which can be used as an anti-photo-ageing agent in skin care. Furthermore, Isoflavone extract helps in the prevention of inflammation reactions, skin cell apoptosis and erythema. [29]

2.10 Kacip fatimah

Labisia pumila, popularly known as Kacip Fatimah is a plant mainly found in Malaysia. The extract is known to show photo protective potential and is used to fight against extrinsic ageing. The collagen synthesis in the human dermal fibroblast cells is up-regulated with the use of *Labisia pumila*. The presence of phenolic acids and bioflavonoids in the herbal extract of *Labisia pumila* has shown the ability to safeguard the human skin from the ROS attack which is generated by the critical UVB exposure [30].

2.11 Greater Burdock

Arctium lappa, popularly known as Greater Burdock is used for the topical treatment in skin care. The fruit extracted from *Arctium lappa* is used as an effective skin care regimen for mature skin which is an effective formulation for the reduction of wrinkles. Arctiin a glycoside – curbs the chronic inflammation in the ageing skin which offers the first cosmetic treatment alternative that targets these subclinical processes in the ageing skin [31].

Many other plants used for their anti-aging and UV radiation protecting effects have been enumerated in Table 1.

3 Parameters for Evaluation of Topical Herbal Formulation

3.1 The pH Value

The pH of a preparation or formulation to find if the formulation prepared is of acid, basic or neutral in nature when tested at room temperature [39].

3.2 The Measurement of Viscosity and Rheology Studies

A programmable viscometer or the Brookfield Viscometer, choosing the appropriate spindle and amalgamating with a software (for e.g., RheoWin 3.61) can be used to measure the viscosities and Rheology of the formulation. A fixed volume of the sample (for example 40mg) can be used for the measurement of viscosity, whereas to study the rheology we increase the shear stress of the preparation to study the conduct of the formulation under stress [39].

3.3 Zeta Potential

A nano-particle analyzer can be used to measure the Zeta potential of the formulation. The samples have to be diluted in double distilled water. At the ratio of 1ml/10 ml and then loaded onto the sample holder which will then be placed into the apparatus. The nano- particle analyzer was used to take automatic measurements and determine the zeta potential values of the preparation [39].

3.4 Spreadability Test

Topical formulation should spread easily and not require too much drag and not create eminent amount of friction in the rubbing process. The Spreadability of a formulation is calculated using the spreadibility apparatus which is made of wooden board, scale and also two glass slides which has two pans on both the sides and mounted on a pulley. Surplus amount of sample can be placed in between the glass slides and then for 5 minutes, 100 g weight can be placed on the slide, which compress the sample to a consistent thickness. Then a weight of 250 g can be placed to the pan and the time can be recorded in seconds which is needed to set apart the two slides and this value can be taken as a measurement of spreadability.

The spreadibility of a formulation is measured by using the following formula [1]:

$S = m * l/t$

where, m – Weight tied on upper slide, l – Length of glass slide, and t – Time in seconds.

3.5 Determination of Water Number

The water number is the uttermost amount of water that can be added to 100 g of the formulation or base at a particular temperature. This is determined by constantly stirring the formulation with the incorporation of distilled water until no amount of water can be absorbed into the base formulation, which is indicated by the droplets of water that is remaining in the vessel; this result is taken at the end point [1].

3.6 Determination of the *in vitro* SPF (Sun protection Factor)

While preparing a sunscreen preparation it is important to measure the SPF or the sun protection factor in which a small amount of the emulsion (for example 1.0g) can be taken and then diluted to a required volume with ethanol. Then it is ultra-sonicated for about 5 minutes and filtered using a cotton filter. After filtration, the filtrate is taken at the start and discard the first 10 ml. After that 5ml of the aliquot is transferred to a 25ml volumetric flask and then the volume is adjusted with ethanol. The absorbance spectra are obtained in the range of about 290-320 nm at every 5nm interval for the samples which is in the solution form. At each point, about three determinations can be made to find the apt value. It is followed by the application of Mansur equation that is;

$$\text{SPF Spectrophotometric} = CF \times \sum_{290}^{320} EE(\lambda) \times I(\lambda) \times Abs(\lambda)$$

where, EE (I) = the erythemal effect spectrum I (I) = the solar intensity spectrum
Abs= absorbance of the sunscreen product, and CF= the correction factor

The value of EE× I is a constant and this study is designed to study and determine the SPF using an ultraviolet (UV) Visible Spectrophotometer [39].

3.7 Estimation of Antioxidant Activity by 1, 1-Diphenyl-2-picrylhydrazyl Assay

A free stable radical known as DPPH is used to measure the antioxidant activities. The basis of the common antigen assay is the scavenging of the DPPH-free radical. For this, 1ml of 100µm DPPH in methanol is mixed with an equal volume of the diluted sample solution in the phosphate buffer pH 7.4, then placed in a test tube and kept in a dark room for about 30 minutes. Then it is incubated for another 30 minutes at 37°C. At 520nm the absorbance of each of the solutions is determined using a double beam UV spectrophotometer. The readings for the corresponding blanks are also taken and the remaining DPPH-free radicals are calculated by using the given formula.

$$\% \text{ Inhibition} = \frac{AbC - AbS}{AbC} \times 100$$

where, AbC= Absorbance of control, and AbS= Absorbance of the sample/standard

This assay is usually carried out using three samples or in triplicates. The measurements are made at six points of concentration. A standard is taken for the study depending on the formulation [39].

3.8 Measurement of The Skin's Moisturization Effect

Corneometer® CM 825 can be used to measure the skin's moisturization. The Corneometer® probe is used to measure the capacitance of the stratum corneum with the help of an electric scatter field, which works by the penetration of the first layers of the stratum corneum (10–20 µm). The variation of capacitance of the probe capacitor due to hydration of skin surface is measured and the moisturization effect can be reported in arbitrary units (corneometric or craniometric units). This measurement can be taken at five different points of the right cheek. The selected measurement points delineate the vertices and the centre of a quadrangle virtually drawn across the cheek. An increase in the Corneometer value is an indication of a skin moisturizing effect [6].

3.9 Measurement of Wrinkle Depth and Skin Roughness

A three-dimensional (3-D) microtopography imaging system is used to measure the wrinkle depth and skin roughness (Ra parameter) on a specific surface of the skin. The imaging system projects structured light, with a digital micro-mirror device and records the image with a CCD camera. Skin surface microtopography is then reconstructed using temporal phase shift algorithms to generate 3-D images. The imaging system has an overlap feature that enables precise matching of photos taken at different visits. To improve image overlap, the subjects' position was regulated using a stereotactic device. Wrinkle depth and skin roughness can be measured in the peri-ocular area using the appropriate software routine. Ra parameter is related to skin smoothness and a decrease of Ra can be expressed in absolute values as an increase in skin smoothness [6].

4. Conclusion and Future Perspective

Over the past few years research on skin care products have undergone tremendous progress. Different herbal topical formulations are expected to be of superior quality and can provide anti-aging and sun protection facilities. Several active ingredients from different natural sources used in topical formulations should provide benefits for the skin without any serious adverse reactions. Efficacy and safety studies of many herbal products depend on good quality research achieved with adequate and consistent methods being used and also the studies being performed. Therefore, today high-quality research in this field is needed to securely establish the efficacy, safety, and benefits of the herbal products used for cosmetic preparations. Nonetheless, questions remain regarding the documentation of regulatory standards, health benefits claims, and the different

methods of evaluation for pharmaceutical effects for the knowledge of the consumers.

Medicinal plants hold a promising future in the field of cosmetic products. There are as many as half a million plants available all around the world, however, almost half of them are not yet investigated and also their full potential and medical activities are still hidden. Additionally, though the positive effects like a decrease in wrinkle depth, increase in firmness and the elasticity of the skin, strengthened skin barrier function and reduced dark spots were noted as the benefits of herbal plant products, further investigation can be made to get additional information about various plants as their full capacity has not yet been studied for skin renewal and other functions like reduction of dark spots etc.

Nowadays the products are targeted at a specific market and the manufacturers have a complete range of products such as high SPF sunblocks, and tanning lotions having both moisturizing as well as sun protection effects. A study needs to be conducted focusing on the products for children, athletes, and also for specific UVA protection. Advanced topical formulations can be prepared in the form of a cooling spray, hydrogels, and thin sprayable gels with a film-forming polymer combined with the emollients and cooling ingredients to fight signs of aging and provide good sun protection to our skin. It can be concluded that compounds of natural origin are more in demand and seeking to replace synthetic substances for the preparation of skin care products. Therefore, recent developments in this area may provide effective and cost-efficient skin care products that would be of great benefit to society.

Conflict of interest

The authors declared no conflict of interest related to this article.

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