

Potential of Natural Compounds as Sunscreen Agents

Rani Mansuri*, Anupama Diwan, Harshit Kumar, Khashti Dangwal, Dharmender Yadav

ABSTRACT

Many skin diseases such as sunburn, pigmentation, wrinkles, dermatitis, urticaria, ageing, skin cancers and immune suppression are due to the extreme exposure to harmful sun radiations. The mere covering of skin through sunglasses, clothes or other external agents is not adequate protection method. Therefore, application of sunscreen is considered as one of the trendiest methods to get rid of the skin aging, sunburn and other related problem arises due to the exposure of ultraviolet radiation (UV) radiations. Sunscreen agents protect from the sun by absorbing the UV and visible sun rays. Herbs have been used in medicines and cosmetics from centuries and their potential to treat different skin diseases, to adorn and improve the skin appearance is well-known. The presented review article is concern with discussion on various plant derived chemicals acting as sunscreen agents such as squalene, peptides, and nucleotides etc and protecting mammalian skin. Herbs and herbal preparations have a high potential due to their antioxidant activity. Antioxidants such as vitamins (Vitamin C, Vitamin E), flavonoids, and phenolic acids play the main role in fighting against free radical species that are the main cause of numerous negative skin changes. Effective botanical antioxidant compounds are widely used in traditional medicine and include tocopherols, flavonoids, phenolic acids, nitrogen containing compounds (indoles, alkaloids, amines, and amino acids), and monoterpenes. Anthocyanin's, Proanthocyanidin, Quercetin, Anthranilate, Resveratrol, Apigenin, Silymarin, Curcumin, Carotenoids are well known plant derived active chemicals that have potential to absorb radiations. This review covers all essential aspects of potential of herbs as radioprotective agents and its prospects.

Key words: UV radiation, Skin diseases, Skin Cancer, Photoprotection, Phytochemicals, Herbal products, Sunscreen.

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INTRODUCTION

Overexposure of sunlight is hazardous to human as it has many detrimental effects on eye, immune system as well as on the skin. There has been records of increase in skin cancer related data as a result of various outdoor activities.^[1] People heading towards beach in only their bath suit so due to extra exposure of sun sunburn happens experts also says that we can prevent skin cancer by 80% by means of avoiding the sun or by having the protective gear that can prevent sun exposure.^[2] As per WHO recommendation, it is essential to put sun screen of broader spectrum (SPF 15+) in plenty amount after popular outdoor activities like, playing, swimming or exercising.^[3,4] The goal of sunscreen formulation is to block UV rays and increase the protection against it.^[4] By not using sunscreen when in the sun can accelerate the skin disease like wrinkles, early aging and skin cancer.^[5] Approximately one out of five people in United States develop skin cancer in their lifetime. The major cause of these disease is exposure to UV radiations such as UV_A and UV_B. UV_B rays are responsible for sunburn^[6] whereas UV_A enter more deeper into tissues that is the main cause of premature aging.^[6,7] Physical barrier just scatter, reflect and block the UV radiation by using various accessories such as goggles, hat and

full sleeve clothes. On the other hand the chemical sun blockers absorb the harmful radiations and shield the skin.^[8] Sunlight is essential for bodily functions like producing Vitamin D and maintaining your mood but too much exposure of sun can also be harmful.^[9] As per the drug and cosmetic act 1940 and the rule in 1945 "cosmetic" means any article intended to be rubbed, poured, sprinkled or sprayed on, or introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance,^[10,11] and includes any article intended for use as a component of cosmetic. A sunscreen contains more than one ingredient some provide protection against UV_A while some against UV_B.^[11] Sunscreen are mainly rated and marketed by the sun protection factor (SPF) that measures the fraction of sunburn.^[12] More will be the SPF more will be the protection.^[13] The SPF can be described as the fraction of UV radiations needed to bring about nominal erythema on skin after application of sunscreen to the amount of energy needed to bring the same effect on skin without application of sunscreen.^[14] Earlier the values of SPF in the marketed sun screen were used to be <1,^[15] but nowadays the trend is not same. The

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recent marketed sun screen are having SPF ranging from 15-20 or even higher up to 50.^[14] The main aim of applying sun screen is to protect skin from sun burn, and that looking in to the aim the value of SPF are maintained.^[16] Based on the skin types, skin is categorised as, skin type I- (skin that never tan but burn easily), skin type II (that readily burn and tan negligibly^[17] and skin type III (burn but tan readily). As per FDA, the chances of skin cancer can be prevented by applying sunscreen (SPF 15 or above) together with the use of physical barriers.^[14,15] If the SPF level is below 15 then the protection will be low, for average protection SPF should be from 15 to 29,^[18] for higher protection it should be from 30 to 49 and value above 50 is required for very high protection. In terms of percentage blockage of radiation, the range of SPF varies from SPF 15 (93% blockage) to SPF 30 (screen about 97%) and SPF 50 (98% blockage of UVB).^[19] Various synthetic and herbal forms of sunscreens are available in market. Many of the synthetic sunscreen agents such as oxybenzone, Octinoxate, Homosalate, nanoparticles, amino benzoic acid, Oxylisadimate, padimate O, or roxadimate are not free from adverse effects such as organ system toxicity, contact allergies, endocrine disruption, photoallergies, melanoma, reproductive toxicity, and can cause skin irritation, hormonal disruption and even skin cancer.^[20]

Herbal products have less side effects on skin than the synthetic one. Herbal sunscreens are non-toxic and non-irritant^[21] and therefore, the recent trend about the use of herbal products is increasing day by day beyond offering desired sun protection from harmful UV radiations.^[22] The herbal phytoconstituent adsorbent of the harmful rays with antioxidants property.^[23] Herbal phytoconstituents like flavonoids, terpenoids, antioxidant, amino acid and glycosides are used in making herbal sunscreen as shown in Figure 1. Most of these have been tested on animal models as well as in *in-vitro* system for their sun protective properties.^[24] In this paper we have attempted to spotlight the essential phytochemical constituent that have sun screening property and are able to protect the skin against the damaging radiation.

PHYTO-PHOTOPROTECTION

Phytoconstituents are very much popular now a days in cosmetic products as they not only prevent the exposure of harmful endogenous and exogenous agents but also protect from many skin diseases.^[25] Overexposure of sunlight can lead to the skin cancer and photoaging,^[26] which results in appearance of fine lines, wrinkles, loose of the elasticity of skin and hyperpigmentation mark can appear.^[27] Herbal extract can heal and soft the skin and also provide sunscreen effects.^[28] We have selected some phytoconstituent like resveratrol, quercetin, silymarin and Vitamin C that are not only good for skin conditioning but also considered good for the development of herbal cosmetic formulation that can diminish the probability of skin cancer and photoaging process.

Flavonoids

These are the secondary metabolites found in the plants and have potential of blocking harmful radiation by absorbing the sunlight in the ultraviolet region, also have antioxidant property and they modulate several signalling pathways.^[29] The presence of flower pigments is a distinguished feature of flavonoid in most of angiosperm families.^[30] However, they are not only found in flowers but are also found in all parts of plant. Flavanols are one of the most important categories of flavonoids which carry ketone group^[31] and it is also the foundation for proanthocyanin. It can be categorised in various sections according to the oxidation, the degree of unsaturation and the carbon of the ring C where the ring B is attached.^[31] Isoflavones are the flavonoid where ring B is attached at position 3 to the ring C.^[32] Neoflavanoids, are linked at to ring B at 4 position of ring C, whereas the compounds where attachment of both the ring occur at 2nd position, are classified in various

subcategories such as flavones, flavanols, flavanols, catechin and its derivatives based on structural features of ring^[31] as shown in Figure 2.

Flavonoids are found in various vegetable, fruit, bark and root of some plants, flower, wine and tea. Flavonoids shows anti-mutagenic, anti-carcinogenic, anti-carcinogenic, antioxidative, anti-inflammatory actions.^[33] UV absorption spectrum of flavonoids has two maximum peaks of absorption, one between 240nm and 280nm and the other at 300-500nm so, they can be used in formulations to block UV_A and UV_B radiations. The plant extract of cinnamates and flavonoids is known for its potential to protect early aging caused by various external factors,^[29] antioxidant properties, absorption of UV rays, usefulness in cosmetics and action against the free radicals.^[24]

Quercetin is obtained from oak plant, that acts as natural inhibitors of auxin.^[3] Quercetin is a flavanol which is classified under six subclasses of flavonoid. The standard IUPAC nomenclature of quercetin is 3, 3,4, 5,7-pentahydroxy-2-phenylchromen-4-one or 3, 3,4,5,7-pentahydroxyflvanone, that indicate the presence of hydroxyl group at various positions of quercetin. It lacks the sugar attachment to aglycone part.^[34] Physically, it appears as brilliant citron yellow with needle shape crystal, which is highly soluble in alcohols and lipids, insoluble in cold water and very less soluble in hot water.^[35] The rich source of quercetin is apple, brassica, berries, grapes, seeds nuts flower, onion, tomatoes, shallots, tea capers, and many bark and leaves.^[36] It helps reduce the effects of free radical damage on skin from UV exposure, flavonoids can also provide a non-negligible level of photoprotection in UV_A range.^[37]

Apigenin is found in various fruit like apple, grapes and cherries, found in various herbs (clove, endive and German chamomile), vegetables (beans, leeks, onion, broccoli, celery, parsley) and beverages (wine and tea).^[38] Chemo preventive agents protects UV-induced skin cancer and also retard DNA damage in cell free system.

Silymarin extract is obtained from oldest herbal plant *S. marianum* seeds.^[40] Silymarin milk thistle is rich constituent of polyphenols.^[39] Silymarin is also used in cosmetic and dermatological preparation for its antioxidant's effects. It also has ability to reduce UV_B and chemical induced damage.^[23]

Terpenoids

Terpenoids or isoprenoids are diverse compounds that are composed of isoprene units (five carbon compound)^[41] that has various basic skeleton and functional groups. The term "terpene" and "terpenoid" are frequently interchanged. Sometime "terpenoids" are included in "terpene", and somewhere they are labelled as modified terpene.^[42] Leryer stated that both of these terms should not be used interchangeably. Terpenes are the chemical constituents that possesses 10-15 carbon and terpenoids are terpenes that are modified by removal of methyl group in place of addition of oxygen to hydrocarbon.^[43] Depending upon the number of isoprene units terpenoids are categorised as mono, sesqui, di, tri with 2,3,4, and 6 isoprene unit respectively.^[44] Steroids, tocopherols, taxanes, artemisinins, ingenanes and cannabinoids are considered as six main class of terpenoids. Many terpenes have biological activities (against cancer, malaria, viral and bacterial diseases and inflammation).^[42] Cinnamate acid and its derivatives are found in plant-based food like, whole grains, vegetable and fruit. 3-phenylprop-2-enoic acid or tizaparin or 3-phenylacrylic acid are the called as cinnamic acid. Other derivatives of this class are of cinnamyl alcohol, cinnamaldehyde and dihydrocinnamyl alcohol.^[45] Its derivatives in cosmetic in UV protection. Provide protection against UV light ranging from minimum photoprotection.^[46] It decreases undesirable effects of sunscreen of this class. Xanthin is found in big concentration in several green leaf vegetable, such as broccoli, spinach kale, cabbage and green mustard leaves etc.^[47] Zeaxanthin fraction

Major plants phytoconstituents with sun screening potential.

Plant Name	Plant Parts	Major Constituents	Mode of Action	References
Flavonoids				
Black carrot (<i>Daucus carota</i>)	Root	Anthocyanins-cyanidin, peonidin, pelargonidin.	Anthocyanins is the antioxidant activities and fortification against DNA injury, these composites being capable to detain hazardous free radicals as singlet oxygen ($1O_2$), superoxide radical (O_2^-), hydroxyl radical (OH^\cdot) and hydrogen peroxide (H_2O_2), chemical groups that direct to lipid peroxidation of cell membranes.	[63]
Marigold (<i>Calendula officinalis</i>)	Flowers	Apigenin	Apigenin effective in the prevention of UVA/UVB-induced skin carcinogenesis.	[64]
Cumin (<i>Cuminum cyminum</i>)	Fruit			[23] [64]
Peppermint (<i>Menthe piperita</i>)	Herbs			
Green and black tea (<i>Camellia sinensis</i>)	Leaves extract	(-)-epigallocatechin-3-gallate (EGCG), (-)-epigallocatechin (EGC), (-)-epicatechin-3-gallate (ECG), and (-)-epicatechin (EC), catechins	1. Topical green tea applied to human skin provide a photoprotective effect, reduced the number of sunburns cells, protecting epidermal Langerhans cells from UV damage, and reduced the DNA damage that formed after UV radiation. 2. Black tea to the skin to soothe sunburn 3. Catechins help prevent and repair skin damage and may even help prevent chemical- and radiation- induced skin cancers.	[65] [38] [66]
Grape seed (<i>Vitis vinifera</i>)	Seed extract	oligomeric proanthocyanidins, Catechin, epicatechin, and taxifolin	1. Grape seed extract in the selected sunscreen lotion resulted in increasing SPF value and had good antioxidant activity. 2. Polyphenols that prevent the generation of reactive oxygen species which suggests an anti-aging action.	[67] [68]
Apple barriers (<i>Malus domestica</i>)	Fruit extract	Quercetin	1. Help reduce the effects of free radical damage on cells from UV exposure. 2. Flavonoids also provided a non-negligible level of photoprotection in the UVA range	[69]
Milk thistle (<i>Silybum marianum</i>)	Seed	Silymarin -flavonoid compound	1. Silymarin can provide substantial protection against different stages of UVB-induced carcinogenesis, possibly via its strong antioxidant properties. 2. Silymarin reduced UV-induced sunburn cell formation and apoptosis. 3. Silymarin treatment prevents UVB-induced immune suppression and oxidative stress <i>in vivo</i>	[70] [25] [71]
Terpenoids				
Camphor (<i>Cinnamomum camphor</i>)	Wood and bark	Enzacamene - 3-Benzylidene camphor - Benzylidene camphor sulfonic acid Camphor benzalkonium methosulfate - 4-Methylbenzylidene camphor - Poly Acryl amido Methyl Benzylidene camphor	All the camphor-derived sunscreens dissipate the photon energy by cis-trans isomerization. However, for Enfacement the quantum yield for this isomerization is only between 0.13-0.3. This low quantum yield means that other photochemical processes are also occurring	[72]

Green, red and yellow plant	Fruit	Zeaxanthin, Canthaxanthin and bcarotene. Isoprenoids, lycopene β -carotene, α -tocopherol, and selenium.	1. The crude extract and the zeaxanthin fraction were incorporated in a gel based sun protective formulation and analysed for the SPF and boot star rating. 2. Oral administration of lycopene β -carotene, α -tocopherol, and selenium reported decreased UV-induced erythema, lipid peroxidation, and sunburn cell formation.	[23]
Tabat barito (Ficus deltooid Jack)	Leaves	Germanicol cinnamate. Glyceryl esters of <i>p</i> -methoxycinnamic acid, 1,3-dipalmitoyl-2- <i>p</i> -methoxycinnamoyl-1,2,3-propanetriol and 1,3-dioctanoyl-2- <i>p</i> -methoxycinnamoyl-1,2,3-propanetriol	1. Provided protection against UV light, ranging from a minimum protection to ultra. 2. Increase substantivity and decrease eventual undesirable effects of sunscreens of this class	[73] [74]
Krameria triandra (Krameria lappacea)	Root extract	octyl methoxycinnamate, 15% neolignans	1. It absorbs slightly more UV light in the 340-380nm range than the organic sunscreen does 2. As topical antioxidants/radical scavengers against skin photodamage. 3. Antioxidant, photoprotective, cytoprotective effect, radical scavenger	[75]
White Willow Bark And Wintergreen Leaves	Bark and leaves	Homomenthyl salicylate (homosalate), ethylhexyl salicylate (octyl salicylate) and trolamine salicylate, spropylbenzyl salicylate, Triethanolamine salicylate Salicylic acid salts (potassium, sodium and triethanolamine).	1. They have weak UVB absorbing properties and are generally used in combination with other chemical absorbing sunscreen agents. 2. Octyl salicylate, are also used to help other UV filters mix into the sunscreen.	[76]
Tea tree (Melaleuca alternifolia) oil	Leaves	terpinen-4-ol, 1,8-cineole,, alpha-terpineol, and gamma-terpinen.	It is an effective antiseptic, fungicide, and germicide. It is a popular component of many sunscreen formulations that relieve sunburn by increasing blood flow in capillaries, bringing nutrients to damaging skin	[23] [77]
Walnut (<i>Juglans regia</i>)	fresh green shells	juglone (5-hydroxy-1,4-naphthoquinone), lawsone (2-hydroxy-1,4-naphthoquinone), seven phenolic compound identified in walnut husk- ferulic acid, vanillic acid, coumaric acid, syringic acid, myricetin, and juglone.	1. Aqueous extract has been shown to be particularly effective as a self-tanning sunscreen agent. 2. Juglone- UV protection properties. 3. Myricetin with antioxidant properties.	[78] [79]
Almond (<i>Prunus dulcis</i>)	fruit	Phenolic acid	The UVB protective property of this plant's skin extract was tested.	
Antioxidants				
Amla (<i>Emblca officinalis</i>)	Fruit extract	1-O-Galloyl- β -D-glucose (β -glucogallin), β -Glucogallin	1. Photoprotection efficacy due to its inhibitory effect on ultraviolet radiation. 2. β -glucogallin can be the active principle which is significantly responsible for the photoprotection efficacy. 3. Strong antioxidant activities against the UV penetration and anti-aging.	[79]

Lemon (<i>Citrus limon</i>)	Fruits and seed extract	Ascorbic acid (Vitamin C)	Vitamin C is capable of additive protection against acute UVB damage (sunburn cell formation) when combined with a UVB sunscreen.	[80]
Orange (<i>Citrus sinensis</i>)				
Mango (<i>Mangifera indica</i>)				
Red grapes (<i>Vitis vinifera</i>)	Grape skins	Resveratrol stilbene (3,5,4'-trihydroxystilbene) phytoalexin antioxidant. polyphenolic phytoalexin	1. Effects of resveratrol against ultraviolet radiation mediated oxidative stress and cutaneous damages including skin cancer [81] 2. Topical application with resveratrol (both pre- and post-treatment) results in inhibition of UVB-induced tumor incidence and delay in the onset of skin tumorigenesis. [82] [25]	
Broccoli	Fruit,	Retinol (vitamin A) and	1. It can serve as an antioxidant to improve product performance [83]	
Cantaloupe	Rhizomes and	palmitic acid	against the aging effects of UV exposure or to enhance the aesthetic [84]	
Squash	Leaf		qualities of sunscreen. [85]	
<i>Triticum vulgare</i> (wheat germ),	Seed, flower, fruit	(α -tocopherol), tocotrienol, linoleic acid	1. Alpha-tocopherol and tocotrienol—effectively reduce skin roughness, the length of facial lines, and the depth of wrinkles. [86] [23]	
<i>Helianthus annuus</i> (sunflower)			2. Vitamin E is a free radical scavenger and an emollient too. [87]	
<i>Sesamum indicum</i> (sesame) oils			3. Tocopherols and phenolics, which account for 59% of the antioxidant effects. [88]	
<i>Cucurbita pepo</i> (pumpkin) seed oil.				
Tomato (<i>Solanum lycopersicum</i>)	Fruit extract	Lycopene	Lycopene scavenges lipid radicals, reduces lipid peroxidation, and prevents erythema caused by UV radiation on the skin. Lycopene may reduce the damaging effect which UV light can have on the skin and can boost protection against both the short term (sunburn) and cumulative effects of sun exposure (cancer)	[89-91]
Pomegranate (<i>Punica granatum</i>)	Fruits	Ellagitannins and anthocyanins.	Applying sunscreen treatments to pomegranate fruit on the degree of sunburn damage and the effect of maturity and sunburn on the internal antioxidant concentration of the juice.	[92,93]
Cucumber (<i>Cucumis sativus</i>)	fruits	ascorbic acid (vitamin C) and caffeic acid,	It also helps remove dead skin cells and tightens skin. Cucumbers soothe skin irritations, prevent water retention and are rich in water, fiber and beneficial minerals.	[94,95]
Indian Beech Tree	Leaves extract	antioxidants	The absorption spectra of various solvent extracts of this plant were measured using UV visible Spectrophotomete. The aqueous and methanol extracts were found to be highly effective in UVB region and moderately effective in UVA region.	[96]
African tulip tree (<i>Spathodeacamp anulata</i>)	bark	antioxidants	The ability of extract to absorb UV radiation and hence proved its UV protection ability. This plant makes it as a better and safe alternative to harmful chemical sunscreens	[97]

Amino acids				
Aloe Vera	Leaves	AMINO ACID-Leucine, Isoleucine, Lysine, Methionine, Phenylalanin, Threonine, Valin, Tryptophan. ANTHRAQUINONES-Chrysophanoic Acid, Emodine. ENZYME-Catalase.	Aloe Vera is a unique and effective moisturizer, and work as a healing agent for the skin.	[98] [23]
Caprylhydroxamic acid	Liquid	Caprylhydroxamic Acid or Octano-hydroxamic Acid	1. It's a gentle preservative that ensures product safety and longevity use. 2. Caprylhydroxamic acid in combination with caprylyl glycol and glycerin to provide gentle, broad spectrum antimicrobial preservation.	
<i>Porphyra</i> (<i>Bangiales, Rhodophyta</i>)	Edible seaweed	Vitamin B12, Amino-acid	Daily UV protective care - Sun care - Anti-photo-aging care.	[99]
Lipids				
Avocado (<i>Persea Americana</i>)	Fruit	Linoleic acid, Oleic acid, Palmitic acid, Omega-3 fatty acids and Vitamins A, D, and Beta Carotene, Lecithin.	1. Avocado oil is very easily absorbed by the human skin, keeping it firm and smooth. 2. Avocados may help to protect the skin from harmful UV radiation.	[100]
Borage (<i>Borago officinalis</i>)	Seed	Borage oil, gamma-linoleic acid (GLA)	1. Borage oil stimulates skin cell activity and encourages skin regeneration. 2. Borage penetrates the skin easily and benefits all types of skin, particularly dry, dehydrated, mature, or prematurely aging skin 3. Treat all kinds of skin inflammation including Eczema, dermatitis, psoriasis and rosacea.	[101]
Evening primrose oil (<i>Oenothera biennis</i>)	seed	gamma-linolenic acid (GLA)	1. Evening primrose skin oil discourages dry skin and premature aging of the skin 2. It soothes skin problems and inflammation.	[101]
Soybeans (<i>Glycine max</i>)	nuts	fatty acids, protein, lecithin,	Used topically on the skin, soybean oil is a cost-effective moisturizer compared to other oils and has a natural SPF of 10	[91] [101]
Glycosides				
Licorice (<i>Glycyrrhiza glabra</i>)	Root extract	Methyl and methyl anthranilate	The Anthranilate are considered to be a photostable (non-degradable upon exposure to UV) class of sunscreens due to the intramolecular hydrogen bonding facilitated by the <i>ortho</i> position of the NH ₂ group with respect to the ester substituent	[102] [103]
Resins				
Turmeric (<i>Curcuma longa</i>)	Rhizome	Curcumin (diferuloylmethane), polyphenolic compounds, curcuminoids, demethoxycurcumin	1. Curcumin can prevent UV irradiation-induced apoptotic changes in human epidermoid carcinoma A431 cells. 2. Curcumin possesses anti-inflammatory, antitumoral, and antioxidant properties.	[104] [25]
Other				
Jasmine (<i>Jasminum officinale</i>)	flowers	Methyl and methyl anthranilate	The Anthranilate are considered to be a photostable (non-degradable upon exposure to UV) class of sunscreens due to the intramolecular hydrogen bonding facilitated by the <i>ortho</i> position of the NH ₂ group with respect to the ester substituent	[105] [106]
Saffron (<i>Crocus sativus</i>)	powder	homosalate	Saffron can be used as a natural UV absorbing agent	[107]

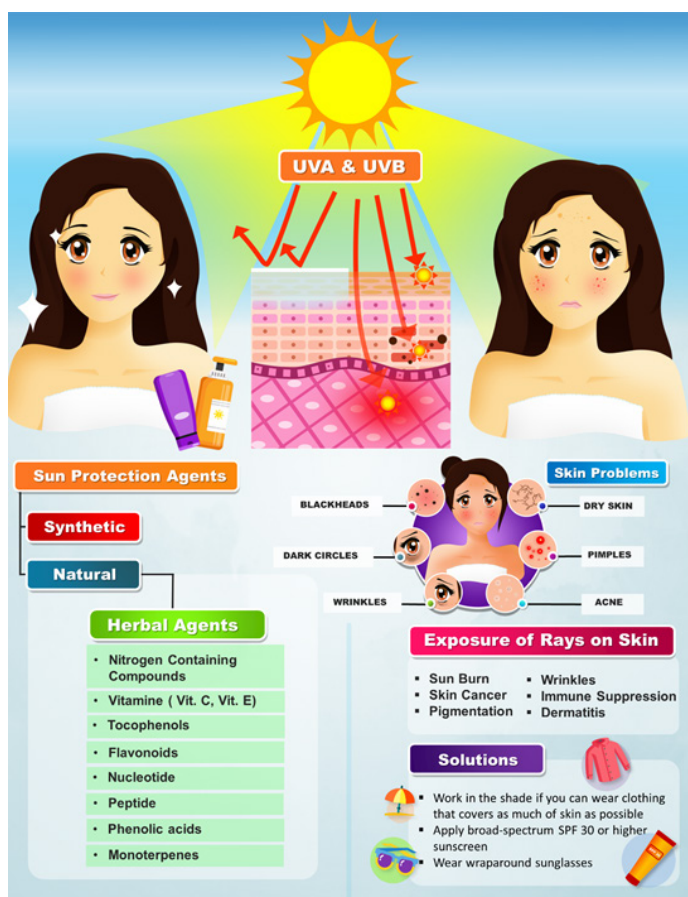


Figure 1: Depicting an overview on harmful effects of UV radiations and ways of protection including herbal agents as sun screening agents.

and the crude extract were incorporated in a gel-based sun protective formulation and analysed for the SPF. Oral administration of selenium, alpha-tocopherol, lycopene and β carotene has demonstrated reduced lipid peroxidation, erythema and formation of sunburn cell on induction by UV rays.^[48] Carotenoid like zeaxanthin/ b- carotene/ canthaxanthin extracted from the thermotolerant genera *Synechocystis*, *pevalekii* is screened for production of UV protective compound and their role in skin protection.^[49] Juglone are made from fresh shell of English walnut, *Juglans regia*. Juglone is predominantly used as a self-tanning agent apart from its sunscreen potential and have antioxidant property.^[50] The chemical structure of terpenoids containing compounds as shown in Figure 3.

Antioxidants

Many phytochemical sunscreen acts as antioxidants including Vitamin C and E, green tea polyphenols and silymarin. Vitamin C (as shown in Figure 4) protects against UV damage, which result in sunburn and erythema. Vitamin E also has many protective action like decreasing immunosuppression, photoaging, erythema and photo carcinogenesis.^[9] Amla is a fruit extract (1-O-Galloyl- β -D-glucose (β -Glucogallin), β -Glucogallin) have photoprotection efficacy due to its inhibitory effect on ultraviolet radiation.^[51] It contains β -glucogallin so significantly responsible for the photoprotection efficacy and have strong antioxidant activities against the UV penetration and anti-aging.^[51]

Resveratrol- Belongs to qualify polyphenolic compounds. It is fat soluble and shows anti- mutagen and antioxidant properties and also shows anti-aging properties. It is mainly found in wine, grape skin, berries juice

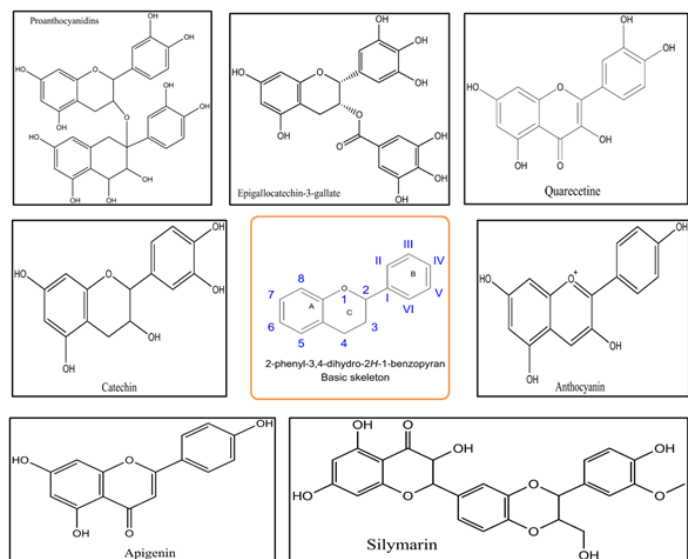


Figure 2: Chemical structure of flavonoids derivatives.

and peanut products. It is very abundant in the roots of weed *Polygonum cuspidatum* and also in leaves of *Veratrum grandiflorum*. Resveratrol also delay the skin tumorigenesis and inhibit the UVB induced tumour incidence. It also induces the human promyelocytic leukemia cell differentiation.^[23]

Ascorbic acid- this is also known as vitamin C. Ascorbic acid helps in adding protection against acute UVB damage. So it is also used in sunscreen for better protection and also sold as a dietary supplement. Also function as an antioxidant. Some salt like ascorbate salt and sodium ascorbate are need in dietary supplement. Deficiency of vitamin C can lead to impaired collagen synthesis.^[52]

Lycopene - It is a plant nutrient with antioxidant properties mainly found in red and pink fruits like tomatoes, pink grapefruit, watermelons. Lycopene linked to heart healthy properties. Test tube study showed that lycopene slows down the growth of breast cancer by limiting tumor growth.^[53]

Lipids

Lipids are a various and prominent group of natural biological compounds and also found in animal, plants and micro organisms. It is present in cosmetic formulation to be applied to skin or protect the skin and enhance the body appearance,^[54] create a protection barriers on the skin from harmful external substance and also help to it keep soft and hydrated.^[55] The major natural ingredients present are lipids plant oil and fatty acids. Plant oil such as Avocado oil (*Persea americana*), Borage oil (*Borago officinalis*), Evening primrose oil (*Oenothera biennis*), Soybeans oil (*Glycine max*). Avocado oil carry main major constituents like Linoleic acid, Oleic acid, Palmitic acid, Omega-3 fatty acids and Vitamins A, D, and Beta Carotene,^[56] Lecithin. The action of Avocado oil herbal formulation is that it is very easily absorbed by the human skin, keeping it firm and smooth and also avocados may help to protect the skin from harmful UV radiation. Borage oil carry main constituents that is gamma-linoleic acid (GLA). Borage oil has various application in skin formulations. It boosts regeneration of skin and also rouses cell activity. It deeply enters to the skin and therefore helpful for preventing inflammation including Eczema, dermatitis, psoriasis and rosacea in different skin types including, dehydrated, dry, prematurely aging and mature skin. Evening primrose oil also contain GLA as active constituent.^[23] Evening primrose oil used in the herbal formulation as it diminishes

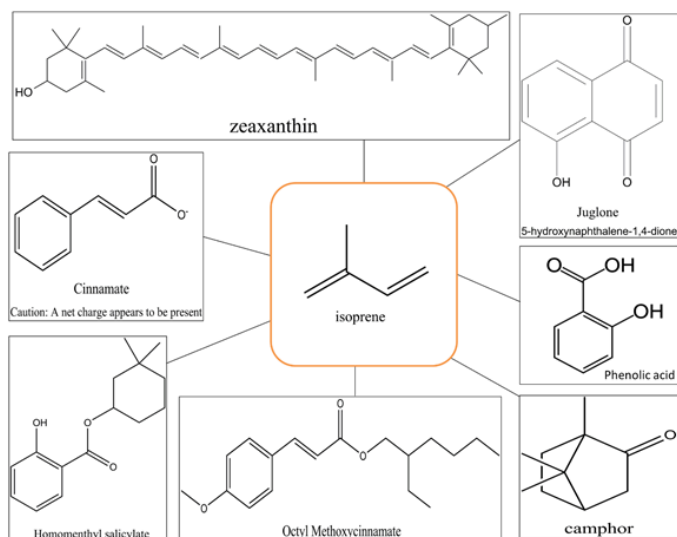


Figure 3: The chemical structure of terpenoids having sun screening property.

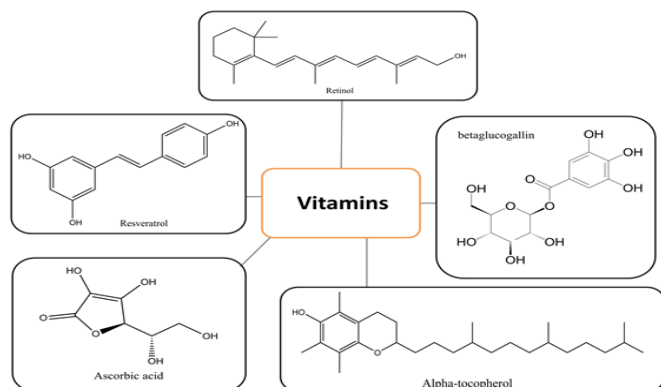


Figure 4: Potential vitamins having anti-oxidant and sun screening property.

premature aging of the skin and dryness. It soothes skin problems and reduces inflammation.^[57] Fatty acid derives oil such as Soybeans (*Glycine max*) carry main constituents such as fatty acids, protein, and lecithin, and are topically applied on the skin. The soybean oil act as cost effective moisturiser and has sun blocking potential (SPF 10).^[58]

Amino acid

The ultraviolet protecting system of lower marine organism and plants have cutaneous photochemical barrier that in human comprises of photo screen (pheomelanin, melatonin and some aromatic amino acids) and photo-sensitisers such as purines, and pyrimidines, retinoic acid, porphyrins, haemoglobin, eumelanin flavin and aromatic amino acids such as tryptophan and its analogues.^[59]

Glycosides

Glycosides like avobenzone act as sun blocker. It blocks the UVA I and UVA II and UVB wavelength and limiting the impact of sun exposure on the skin. It is also safe in terms of toxicity, but avobenzone only provide 30 minutes of protection in the sun because it breaks down quickly.^[21]

Anthraquinone Glycosides: There are naturally occurring phenolic compound based on the anthraquinone skeleton. Mainly anthraquinone glycosides are used in the production of hydrogen peroxide and derivatives of 9-10 anthraquinone include drug like antimalarial,

antineoplastic used in the treatment of cancer like pinoxantone. Natural anthraquinone also shows laxative effect.^[60]

Liquorice (*Glycyrrhiza glabra*): The extract of *G. glabra* and its main constituents has various potential activities also useful in cosmetic herbal formulation and dermatological products.^[61] Glabridin, glycyrrhizin is a major constituent of liquorice that contain many properties and potentially beneficial in cosmeceutical formulation. The Glabridin acts as an anti-inflammatory, antioxidants and skin whitening agents. The root extract of *G. glabra* protect the skin against oxidative stress injuries.^[62]

FUTURE PERSPECTIVE

The exposure to harmful radiations may lead to many skin diseases including skin cancer. The ideal sun screen should be cheaper, effective, safe and should have tendency to block UV rays. With the use of synthetic chemicals (oxybenzone, Octinoxate, Homosalate, nanoparticles, amino benzoic acid, Oxyisadimate, padimate O, roxadimate etc) for the protection of radiations, may led to other toxic effects such as contact allergies, endocrine disruption, photoallergies, melanoma, reproductive toxicity, skin irritation, hormonal disruption etc. Therefore, nowadays the use of herbal sunscreen formulation is rapidly replacing the fashionable sunscreen with harmful effects. Hence moving on with the idea with natural ingredients and metabolites of plant because they have the ability to protect themselves from UV radiations due to the presence of active pharmacophores such as antioxidants, lipids, vitamins, terpenoids, flavonoids, lipids, resins, phenolic acid, amino acid, and enzymes etc. Therefore, present study reveals the potential of natural plant constituents and their effects against UV induced sun burns, cancers etc. The discovery of newer naturally derived sunscreens requires further intensive work by researchers. Therefore, the present paper may be helpful for the researchers and scientists to discover and formulate newer plant derived chemicals with sun protection activity with a target of minimum cost and high efficacy.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ABBREVIATIONS

UV: Ultra violet; **WHO:** World Health Organisation; **SPF:** Sun Protection Factor; **FDA:** Food and Drug Administration; **IUPAC:** International Union of Pure and Applied Chemistry.

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