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Review Article

Herbal Cosmeceuticals for Photoprotection from Ultraviolet B Radiation: A Review

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Abstract

Ultraviolet B (UVB) rays vary with time and season and are the major cause of sunburns. Sunburned skin is a leading risk factor for melanoma and non-melanoma skin cancers. Protection against exposure to UVB rays may be achieved by a combination of various approaches such as use of broad spectrum sunscreen formulations. UV radiations (UVR) absorbed by the skin surface can produce harmful compounds called free radicals or reactive oxygen species (ROS), which can cause skin cancer and premature aging. To reduce ROS generation and damage, researchers recommend using sunscreen to protect the skin from harmful UVR. The realm of possibilities in photoprotection may include the development of sunscreens which remain at the surface of the skin for a longer time and may incorporate antioxidants that can neutralize ROS. By quenching free radicals, antioxidants may aid photoprotection effect. This review focuses on photoprotection from UVB radiation and discusses potential herbal candidates with antioxidant properties that can serve as a strong barrier in cosmeceuticals to protect skin against harmful UVB rays.

Keywords: *Cosmeceutials; Herbs; Reactive oxygen species (ROS); Photoprotection; Antioxidant activity; Ultraviolet radiations*

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INTRODUCTION

Ultraviolet (UV) radiation is defined as that portion of the electromagnetic spectrum between x rays and visible light, i.e., between 40 and 400 nm (30–3 eV). The UV spectrum is divided into Vacuum UV (40-190 nm), Far UV (190-220 nm), Ultraviolet C (UVC) (220-290 nm), Ultraviolet B(UVB) (290-320), and Ultraviolet A (UVA) (320-400 nm). UVA can be further divided into UVA I (340 - 400 nm) and UVA II (320 - 340 nm) [1]. Solar UVR at the earth's surface comprises approximately 95 – 98 % UVA and 2 – 5 % UVB, all the UVC being absorbed by stratospheric ozone. Solar UVB radiation at any location, in cloudless sky conditions, depends on the solar zenith angle, column ozone content and column aerosol content as well the altitude of the observation site [2]. The frequency of ultraviolet type B or UVB is largely responsible for erythema of sunburn and suntan of the skin. Once human skin is exposed to UVB, it is absorbed by DNA of keratinocyte [3]. Its high energy radiation, which is dependent on its wavelength, causes not only sunburn but also skin ageing, skin cancer, etc [4].

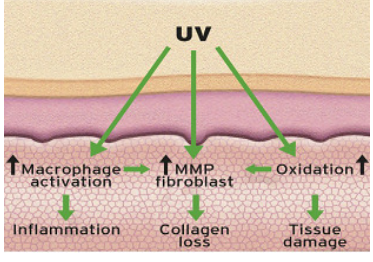


Fig 1: A schematic illustration of UV-induced inflammation, collagen loss and tissue damage

There is no Occupational Safety and Health Administration (OSHA, United States) standard for exposure to ultraviolet light, but the National Institute for Occupational Safety and Health (NIOSH, United States) recommends that the time of exposure to an intensity of 100 microwatts per square centimeter at a wavelength of 254 nm should not exceed 1 min. When averaged over an eight-hour work day, this value is 0.2 microwatts per square centimeter. Factors affecting protection from harmful UVR include behavior, environment, legislation and personal protection. Personal measures are obviously needed to avoid the harmful effects of repeated exposure to ultraviolet radiation.
When UVR interacts with skin surface, biochemical changes in collagen, elastin and connective tissues, which are responsible for skin firmness and elasticity, start to occur [5]. As skin becomes less elastic, it gradually becomes drier and looks wrinkled. This paper will highlight and place in perspective studies and works related to herb-based cosmetics for photoprotection and associated body changes such as ageing and facial wrinkles.

The human body's photoprotection capacity

Paradoxically, when the skin is stimulated by ultraviolet radiation, the skin's self-protection mechanism is 2-fold. First, the swelling of the epidermis by UVB radiation increases protection by 3 to 4 times. Second, increase in the synthesis of melanin (tanning) induced by UVB and UVA radiation, gives the skin 2 to 3 times more protection.

Sunscreen Cosmetics for Photoprotection

The use of sunscreen as photoprotecting agents for UV protection is becoming very popular. Sunscreens are used to aid the body's natural defense mechanisms to protect against harmful UV radiation from the sun. Its function is based on its ability to absorb, reflect or scatter the sun's rays. The Sun protection factor (SPF) of a sunscreen is calculated by comparing the amount of time needed to produce sunburn on sunscreen-protected skin to the amount of time needed to cause sunburn on unprotected skin. Higher SPF sunscreens offer greater protection from sunburn.

Thus, prevention of premature ageing of skin and defense against possible skin cancer may be acquired by employing sunscreen

cosmetics. In the United States, the Food and Drug Administration (FDA) states that any cosmetics with sun protection property must comprised of one or more active ingredients chosen from a regulatory list [6]. These ingredients include protective chemicals and ultraviolet (UV) filters which must be listed on sunscreen labels. Before sale to consumers, the finished product must prove its protective ability in a test conducted on human volunteers. Similar rules govern sunscreens around the world. If a product label implies in any way that the product protects from the sun, then it is a sunscreen. Applying a sunscreen to skin changes the way the body reacts to the sun's rays. In a way, sunscreens are like products which are to be applied on skin to enable it remain healthy and protective. If the sunscreen product contains a herbal antioxidant, it should be applied just before exposure to the sunlight and after every two hours depending on the activity of the person [7]

Swimming, excessive perspiration and drying off with a towel are some of the actions which may minimize the effectiveness of a sunscreen product. Experimental measurements of SPF are determined by applying the product in significant quantities (2 mg/cm^2 of skin). In practice, it has been found that consumers actually apply lower quantities than this. This means that the effective SPF will be less than the figure indicated on the product label and protection from UVB radiation and sunburn is likely to be reduced. Thus, using formulations with SPF higher than 15 is probably advisable for those who need better photoprotection [8].

Benefits of Herbal Cosmetics for Photoprotection

A number of people with sensitive skin, such as those suffering from skin hypersensitivity don't want to use chemical sunscreens due to concern about skin exposure to unknown chemicals. Although a variety of hypoallergenic cosmetic products have been introduced for customers with sensitive skin, there are still limited options in sunscreen agents. Now, however, researchers have claimed that cosmetics having herbal components are more suitable for hyperallergic skin because they are less irritant and more easily adjustable to skin. Topical cosmetic formulations are the most preferred treatments asked by patients and are also often most prescribed by family physicians and dermatologists for sun burn. Patients feel more comfortable using topical therapies because they have milder side-effects, are easier to use, are generally less expensive and are more readily available [9]. Herbal cosmetics must have one or more active sunscreening agent with antioxidant properties in order to achieve good photoprotection effect.

The concept of complementary or alternative medicine is increasingly becoming more widely accepted and there is a corresponding rising interest in herbal remedies. Recently, the role of herbal drugs, herbal products and certain phytochemicals in the control of ageing has been shown [10] .

Some Important Photoprotective Agents

The important photoprotecting agents (fig 2) include a number of constituents often incorporated in a cream base at different concentrations and used as herbal sunscreen cosmetics. Plants with photprotective properties include the following:

1. *Luffa cylindrica*

L. cylindrica (Linn) M. Roem. is a climber with a slender, slightly hairy stem with little furrowing. The seeds of *L. cylindrica* contain oil in which the fatty acids are stearic and linoleic acids - are unsaturated fatty acids [11]. It has been reported that naturally occurring unsaturated fatty acids and phenolic compounds have free radical scavenging properties[12] In a study by

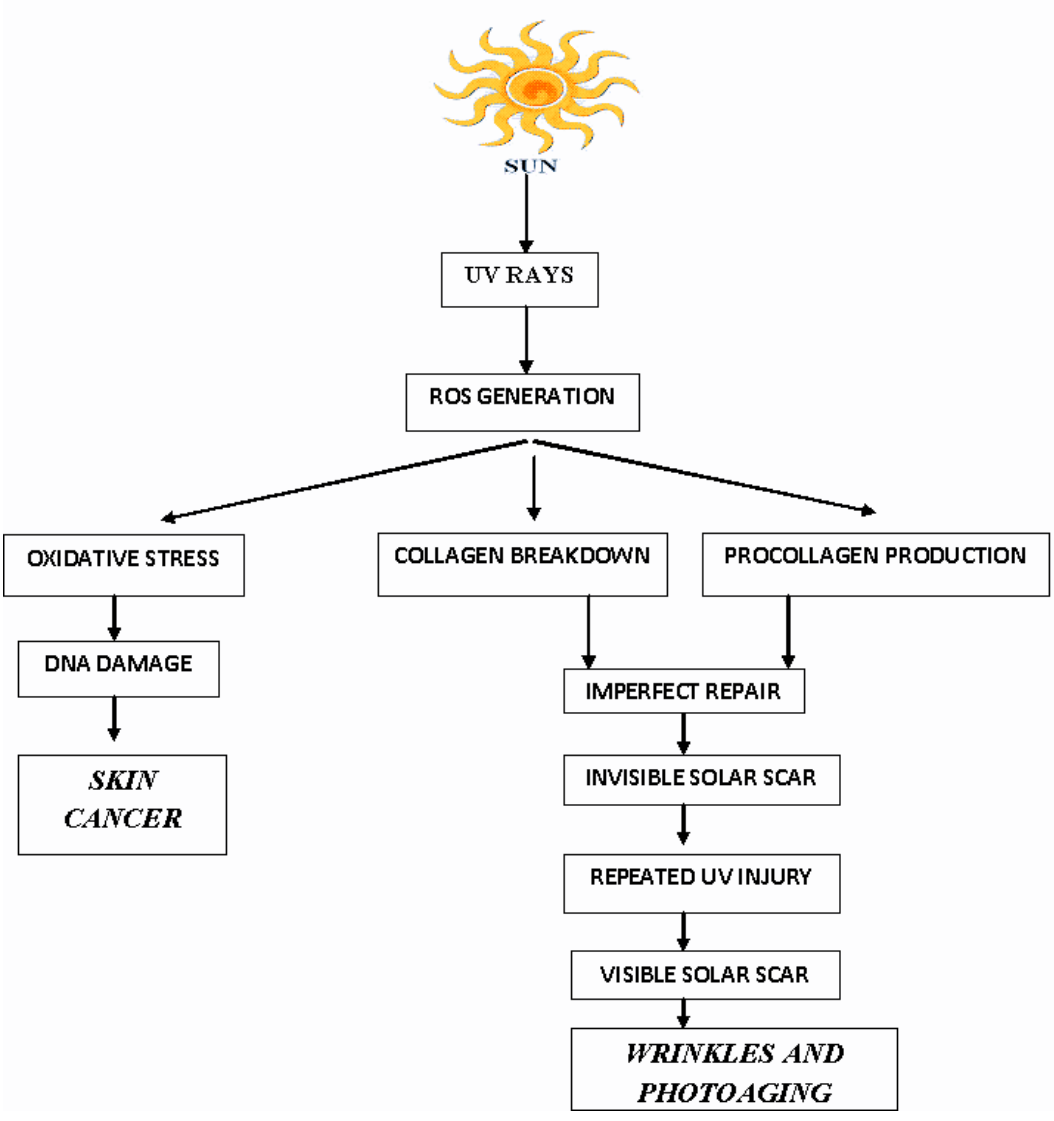


Fig 2: Effect of ROS on skin

Yoganandam *et al* [13], it was concluded that the fixed oil isolated from the seed kernels of the plant not only scavenges off the free radicals but also inhibits generation of free radicals**.**

2. *Portulaca oleracea*

Portulaca oleracea (Common Purslane; also known as Verdolaga, Pigweed, Little Hogweed or Pusley) is an annual succulent in the family Portulacaceae, which can reach 40 cm in height. It is found throughout India and the Middle East, but is naturalized elsewhere, and in some regions, is considered an invasive weed. The whole plant is considered antiphlogistic (takes the heat out), a bactericide, antidiabetic, anaphrodisiac (opposite to aphrodisiac), emollient, calmative, diuretic, and refreshing agent [14,15]. Sanja *et al* has proved the anti-oxidant activity of the methanol extract using

methods such as DPPH free radical scavenging, reducing power estimation by $FeCl_3$, nitric oxide free radical scavenging, super oxide scavenging activity [16]. The extract has a tendency to scavenge the free radicals involved in the ageing process and skin wrinkling and thus may provide some photoprotective action.

3. *Terminalia chebula*

Terminalia chebula, also called Harde, belongs to the family Combretaceae. It is used commonly in many Ayurvedic preparations as laxative, diuretic and cardiotonic, as well as in some health supplements[17]. Its chemical constituents include ascorbic acid, gallic acid and ellagic acid, which are well known to exert free radical scavenging properties [18].

4. *Piper longum*

Piper longum L. belonging to the family Piperaceae, is commonly found in Indonesia, India and the Phillipines. It consists of a spike of fruits forming a structure about 4 cm long and 6 mm in diameter. The fruit (pepper) contains 1 - 2.5 % volatile oil, 5 – 95 % of crystalline alkaloid piperine and piperettine, and a resin [19]. Piperine extracted from this plant has been used as an ingredient in Ayurvedic formulations because of its anti-oxidant potency both *in vitr*o and *in vivo* in mice.[20]. Piperine, due to this antioxidant property, is used topically in a cream base to treat sunburn diseases [21].

5. *Aloe vera*

The leaves of *Aloe vera* (*A. barbadensis*) (Fam. Liliaceace) are the source of aloe vera gel. The gel does not include the sap of *Aloe vera*, which contains anthraquinones. Aloe vera gel is widely used in cosmetics and toiletries for its moisturizing and revitalizing action [22,23]. The whole leaf of *Aloe vera* is known to aid cellular repair as well as digestion, assimilation of foods, vitamins, minerals and other vital nutrients to rejuvenate the skin [24]. The fresh gel, juice or formulated products have been used for medical and cosmetic purposes and to enhance general health [25].

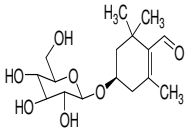
6. *Emblica officinalis*

Emblica officinalis Gaertn., commonly known as amla, is a rich dietary source of vitamin C, minerals and amino acids [26]. It also contains various phenolic compounds. Amla extract is known to exhibit potent antioxidant properties and to provide protection for human dermal fibroblasts against oxidative stress and therefore, it is assumed to be useful for natural dermal care [27]. Recently, it was reported that amla extract has effect on human skin fibroblasts, especially production of procollagen and matrix metalloproteinases (MMPs) [28]. The water extract from dried amla powder contains 2 % ascorbic acid and 29.4 % polyphenols including gallic acid and elaeocarpusin [29]. Amla extract elevates the mitochondrial activity of human skin fibroblasts and promotes production of procollagen. Therefore, due to its potential mitigative, therapeutic and cosmetic applications, amla has been used for skin treatment since ancient times [30].

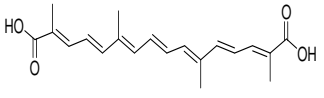
7. *Crocus sativus*

Saffron, the dried stigma of the plant *Crocus sativus* L, popularly used as a spice and food colorant, has been used in traditional medicine for the treatment of many diseases including tumors. The chemical constituents of saffron include the colored carotenoids - crocin and crocetin - and the monoterpene aldehydes - picrocrocin and saffranol [31]. Salomi *et al* reported the anti-promoting and non-mutagenic activity of saffron extract [32]. Lin *et al* showed that crocins can protect from the adverse effects of hepatocarcinogenic compounds and that crocetin, the deglycosylated crocin derivative, can inhibit intracellular nucleic acid synthesis [33]. The anticarcinogenic effect of the aqueous infusion of saffron, administered orally, using a two-stage skin carcinogenesis model in

mice, has been evaluated; the protective role of saffron against carcinogenic exposure was attributed to its action on the physiological detoxification processes and this proved that saffron can prevent chemically-induced skin carcinogenesis in Swiss albino mice [34].



Picrocrocin [35]



Crocetin [36]

8. *Peumus boldus* Molina

Peumus boldus belonging to the family Monimiaceae *(*a tree whose leaves have been traditionally employed in folk medicine) is now widely recognized as an herbal remedy by a number of Pharmacopoeias. Its leaves are rich in several aporphine-like alkaloids, among them, boldine, which is the most abundant one [37]. Research conducted during the early 1990s claimed that boldine is one of the most potent natural antioxidants. Its pharmacological actions, which arise from its antioxidant properties, includes cyto-protective, anti-tumor promoting, anti-inflammatory, anti-diabetic and antiatherogenic actions; it has also shown some actions which do not seem to be associated with these activities, e.g., vasorelaxing, anti-trypanocidal, immuno- and neuro-modulator, cholagogic and/or choleretic actions. Free radicals are known to participate in either the aetiology or the development of most UV-induced skin lesions [38]. Through the experiments conducted on boldine, it has been proved that boldine has a UV light-filtering property relevant to a photo-protective action. In fact, Hidalgo *et al* showed boldine to be photo-unstable when irradiated at wavelengths up to 300 nm and to display a photo-protector effect against UV-B, both *in vitro* and *in vivo* in mice [39]. Photo-protection was evidenced by the prevention of UV-induced increase in the skin temperature of rodents. Recently, Rancan *et al* investigated the photo-filtering properties of boldine in humans and found that application of boldine (25 mM) onto a 12 cm^2 area of the back of volunteers protected their skin against erythema formation to an extent slightly lower than that of a commercial sun cream [Nivea sun spray LSF -5] which has a UV-protection factor of 5 [40].

There are number of plants, with antioxidant potentials, which are generally used in common diets and may play a role in treating free radical generated conditions such as sunburn, wrinkles, and ageing. Some of these plants are listed in Table 1.

Some Commercially Available Herbal Antioxidant Cosmeceuticals

A number of cosmetics manufacturer have incorporated some of the natural antioxidants mentioned earlier in cosmetic formulations. Some examples of these are listed in Table 2.

CONCLUDING REMARKS

Herbal cosmeceuticals are natural products whose ingredients have properties to rejuvenate and protect the skin from environmental pollution, chemicals, atmospheric temperature fluctuation, Ultraviolet A and Ultraviolet B radiation, wrinkling, hyper pigmentation (excessive tanning) and inflammations. The present review focuses on scientific account on use of herbs in cosmetics. In future, more effective formulations containing herbal component may come in trend. The addition of herbal extracts for therapeutic use requires better understanding of herbal potential. The present trend towards herbal cosmetics with effective therapeutic property will continue and may be some newer herbs will also be placed in cosmetics world. In coming future, the regulatory authorities will need to frame some laws concerned with safety, efficacy and quality assessment of these newer herbal cosmeceuticals.

Table 1: Plants with antioxidant potentials as well as anti-wrinkling and anti-aging properties and are commonly used in diet

Plant name	Part preferentially used	Responsible constituent	Ref.
Solanum lycopersicum (Tomato)	Fruits	Lycopene	41
Camellia sinensis (Green tea)	Leaves	Epigallocatechin gallate	42
Malus domestica (Apple)	Fruits	Quercetin, Epicatechin	43
Citrus limon (Lemon)	Fruits	Ascorbic acid	44
Butyrospermum parkii	Fruits	Stearic and oleic acids	45
Anthemis nobilis) (Roman Camomile)	Leaves	2-methyl butanoic acid ester	46
Actostaphylos uva-ursi (Bearberry)	Leaves	Hydroquinone mono - -glucoside,myricetin, quercetin	47
Helianthus annuus (Sun Flower)	Flowers	Vitamin E	48
Punica granatum (Pomegranate)	Fruit	Vitamin$B_{5,}$Potassium, polyphenols and Vitamin C	49
Daucus carota (Carrot)	Root	Vitamin A, Sitosterol,Laserine, Epilaserine	50
Brassica oleracea (Cabbage)	Leaves	Vitamin C, indole-3-carbinol	51
Curcuma longa (Turmuric)	Rhizomes	Curcumin, Zingiberine	52
*Annona squamosa (*Sugar-apple)	Fruit and seed	Liriodenine, moupinamide, α – Pinene	53
Cocos nucifera (Coconut)	Fruit and all parts	Vitamin B, Vitamin C etc	54
Allium sativum (Garlic)	Plant's bulb	Homocysteine, allicin (diallyl thiousulfinate or diallyl disulfide)	55
Glycyrrhiza glabra (Liquorice*)*	Root	Glycyrrhetinic acid, Stearyl glyryrrhetinate	56
Morinda officinalis (Indian mulberry)	Root	Constituent not reported	57
Curcuma aromatica (wild turmeric)	Rhizome	Constituent not reported	58
Gmelina arborea (Gambha)	Bark	Constituent not reported	59
Ginkgo biloba (Maidenhair tree)	Leaf	**Ginkgolides and Bilobalide**	60

Table 2: Some branded herbal cosmeceuticals for photoprotection of skin from harmful UVB radiations

Branded product	Herbs constituent	Manufacturer	Purpose
Tomato Sun Cream SPF 36 PA++	Tomato	Skinfood Cosmetics, South Korea	Anti-wrinkle and sunscreen cream
Natural Sun SPF 25	Green Tea, Aloe vera	Aubrey Organics, United States	Sunscreen cream
Sunscreen SPF +80	Apple	Greenoo ®, Syria	Sunscreen cream
Power Light Intensive Fairness Moisturizer SPF 15	Lemon, Long Dan	Garnier , England	Sun protecting fairness cream
SPF30 natural mineral sunscreen	Shea butter, Jojoba	John Masters ™ Organics, New York	Sunscreen cream
Aroma sun tanning gel cream SPF 10	Roman camomile, Geranium, Jasmine	Declore, Paris	Sunscreen gel
Saffron and bearberry fairness cream	Saffron, Bearbery	Jovees, India	Fair complexion cream
Body lotion	Sun flower oil	Cosmetics Bakery, Singapore	Body lotion
HydraLight moisture-infusing lotion	Pomegranate, Oat, Cranberry	Paula's Choice, Canada	Antioxidant, anti-aging, moisturizer lotion
Bio-pro carrot protective cream SPF 15	Carrot oil	Biotique Botanical Herbal Extracts, India	Sunscreen cream
Even out face cream SPF 20	Liquorice	Oriflame Cosmetics, Sweden	Sunscreen cream
Antiwrinkle Moisturizing lotion SPF 30	Emblica	S B Cosmetics Inc, Florida	Anti-wrinkle lotion
Resist Super antioxidant concentrate serum	Turmeric	Paula's Choice, Canada	Antioxidant serum
Biovera SPF 75	Aloe vera	Biotique Botanical Herbal Extracts, India	Protective body lotion
Save face & body sunscreen SPF 15	Bitter orange	Arbonne Cosmetics. U.S.A.	Sunscreen lotion

REFERENCES

1. *Webber LJ, Whang E, Fabo DEC. The effects of UVA-I (340-400 nm), UVA-II (320-340 nm) and UVA-I+II on the photoisomerization of urocanic acid in vivo. Photochem Photobiol, 1997; 66(4): 484-492.*
2. *McKinlay A, Diffey BL. A reference action spectrum for ultraviolet induced erythema in human skin. In human exposure to Ultraviolet Radiation. Risks and Regulations, Elsevier, Amsterdam, Netherlands, 1987, p 83.*
3. *Puvabanditsin P, Vongtongsri R. Efficacy of Aloe vera cream in prevention and treatment of sunburn and suntan. J. Med. Assoc. Thai., 2005; 88(4): S173-176.*
4. *Farrukh A, Mohammad AZ, Naghma K, Mark D, Hasan M. Protective effect of pomegranate-derived products on UVB-mediated damage in human reconstituted skin. Experimental Dermatol. 2009; 18(6): 553–561*
5. *Kaplan DL, Moloney SJ, Pinnel SR. A new stabilized ascorbic acid solution: Percutaneous absorption and effect on relative collagen synthesis. J. cutaneous aging & cosmetic dermatol., 1988; 1(2): 115-121.*
6. *Oliveira SL, Mansanares AM, Silva EC , Barja PR. In vitro determination of the sun protection factor of sunscreens through photoacoustic spectroscopy: A new approach. The Euro. Phys. J. - special topics., 2008; 153(1): 475-478.*
7. *Moyal DD, Fourtanier AM. Broad-spectrum sunscreens provide better protection from solar ultraviolet-simulated radiation and natural sunlight-induced immunosuppression in human beings. J Am Acad Dermatol., 2008; 58(5): S149-154.*

8. Ho TY. Sunscreens: Is looking at sun protection factor enough? Hong Kong Dermatol. & Venereol. Bull., 2001; 9(3): 107-111.
9. Vender RB. Topical acne therapies: Optimizing patient compliance. Skin Therapy Letter - Family Practice Edi., 2008; 4: 1-4.
10. Kapoor VK, Dureja J, Chadha R. Herbals in the control of ageing. Drug Discov. Today., 2009;14(19-20): 992-998.
11. Satyavati GV, Raina MK, Sharma M. Indian Medicinal Plants, ICMR, New Delhi, 1976, p 178.
12. Gupta VK, Sharma SK. Plants as natural antioxidants-A review. Nat. Prod. Rad., 2006; 5(4): 326-334.
13. Prakash YG, Ilango K, Kumar S, Elumalai A. In vitro antioxidant activity of Luffa cylindrica seed oil. J. Global Pharma Technol., 2009; 2(3): 93-97.
14. Boulos L. Medicinal Plants of North Africa. Reference publications, UK, 1983, p 70.
15. Nadkarni KM, Nadkarni AK. Indian Materia Medica. Popular Prakashan, Delhi, 1999; p 106.
16. Sanja SD, Sheth NR, Patel NK, Patel D, Patel B. Characterization and evaluation of antioxidant activity of Portulaca oleracea. Intern J. Pharm & Pharmaceutical Sci., 2009; 1(1): 5-10.
17. Billore KV, Yelne MB, Dennis TJ, Chaudhari BG. Database on medicinal plants used in Ayurveda. Vol. 3. New Delhi, Central Council for Research in Ayurveda and Siddha, 2005. pp 283-284.
18. Naik GH, Priyadarsini KI, Mohan H. Radioprotecting ability and phytochemical analysis of an Indian medicinal plant: Terminalia chebula. BARC Newsletter(Founder's Day Special Issue). 2002; 1: 22-26.
19. Koul IB, Kapil A. Evaluation of the liver protective potential of piperine. Planta Med., 1993; 59: 413-417.
20. Balachandran P, Govindarajan R. Cancer - An Ayurvedic perspective. Pharmacol. Res., 2005; 51: 19–30.
21. Koul IB, Kapil A. Barthakur MNN, Arnold NP. Evaluation of the liver protective potential of piperine, an active principle of black and long peppers. Planta Med., 1993;59:413–7.
22. Vogler BK, Ernst E. Aloe vera: A systematic review of its clinical effectiveness. British. J. Gen. Pract., 1999; 49: 823–828.
23. West DP, Zhu YF. Evaluation of Aloe vera gel gloves in the treatment of dry skin associated with occupational exposure. Am. J. Infect. Control, 2003; 31: 40–42.
24. Ramachandra CT, Ramachandra P. Processing of Aloe Vera Leaf Gel: A Review. Amer. J. Agri. Biol. Sci. 2008; 3 (2): 502-510.
25. Chithra P, Sajithlal GB, Gowri F. Influence of Aloe vera on collagen characteristics in healing dermal wounds in rats. Molecular and Cellular Biochemistry, 1998; 181: 71–76.
26. Barthakur NN, Arnold NP. Chemical analysis of the emblic (Phyllanthus emblica L.) and its potential as a food source. Scientia Horticulturae., 1991; 47(1): 99-105.
27. Fujii T, Wakaizumi M, Ikami T, Saito M. Amla (Emblica officinalis Gaertn.) extract promotes procollagen production and inhibits matrix metalloproteinase-1 in human skin fibroblasts. J Ethnopharmacol., 2008;119(1):53-7.
28. Yokozawa T, Kim HY, Kim HJ, Tanaka T, Sugino H, Okubo T, Chu DC, Juneja LR. Amla (Emblica officinalis Gaertn.) attenuates age-related renal dysfunction by oxidative stress. J. Agri. Food and Chem., 2007; 55: 7744–7752.
29. Anila L, Vijayalakshmi NR. Flavonoids from Emblica officinalis and Mangifera indica-effectiveness for dyslipidemia. J. Ethnopharmacol., 2002; 79: 81–87.
30. Kim J, Hwang JS, Cho YK, Han Y, Jeon YJ, Yang KH. Protective effects of (–)-epigallocatechin-3-gallate on UVA- and UVB-induced skin damage. Skin Pharmacology and Applied Skin Physiology, 2001; 14: 11-19.
31. Abdullaev FI. Biological effect of saffron. Biofactors, 1993; 4: 83-86.
32. Salomi MJ, Nair SC, Panikkar KR. Inhibitory effects of Nigela sativa and saffron (Crocus sativus) on chemical carcinogenesis in mice. Nutr. Cancer, 1991; 16: 67-72.
33. Lin JK, Wang CJ. Protection of crocin dyes on the acute hepatic damage induced by aflatoxin B1 and dimethylnitrosamine in rats. Carcinogenesis, 1986; 7: 595-599.
34. Das I, Chakrabarty RN, Das S. Asian Pacific J. Cancer Prevention, 2004; 5: 70-76.
35. Petros AT, Moschos P, Michel M. Separation of picrocrocin, cis-trans-crocins and safranal of saffron using high-performance liquid chromatography with photodiode-array detection. Journal of Chromatography A.,1994;664(1): 55-61.
36. John C L. Saffron- A Review. Leffingwell Reports., 2002; 2 (5): 1-5.
37. Peter OB, Catalina CP, Hernan S. Boldine and its antioxidant or health promoting properties. Chemico-Biological Interactions, 2006; 159: 1–17.
38. Griffiths HR, Mistry P, Herbert KE, Lunec J. Molecular and cellular effects of ultraviolet light-induced genotoxicity. Crit. Rev. Clin. Lab. Sci., 1998; 35: 189–237.
39. Hidalgo ME, Gonzalez I, Toro F, Fernandez E, Speisky H, Jimenez I. Boldine as a sunscreen, its photoprotector capacity against UVB radiation. Cosmet. Toiletries, 1998; 113: 59–66.
40. Rancan F, Rosan S, Boehm K, Fernandez E, Hidalgo ME, Quihot W, Rubio C, Boehm F, Piazena H, Oltmanns U. Protection against UVB irradiation by natural filters extracted from lichens. J. Photochem. Photobiol., 2002; 68: 133–139.
41. Ravichandran G, Bharadwaj VS, Kolhapure SA. Evaluation of the efficacy and safety of "Anti-Wrinkle cream" in the treatment of facial skin

wrinkles: A prospective, open, phase III clinical trial. The Antiseptic, 2005; 102(2): 65-70.

42. *Sharangi AB. Medicinal and therapeutic potentialities of tea (Camellia sinensis L.) – A review. Food Res Inl, 2009; 42: 529–535.*
43. *Solovchenko A, Schmitz-Eiberger M. Significance of skin favonoids for UV-B-protection in apple fruits. J Exptal Bot,2003; 199: 1- 8.*
44. *Apak R , Guçlu K , Demirata B , Özyürek M , Çelik SE , Bektaşoğlu B , Berker KI , Ozyurt D . Comparative Evaluation of Various Total Antioxidant Capacity Assays Applied to Phenolic Compounds with the CUPRAC Assay. Molecules, 2007; 12: 1496-1547.*
45. *Vertuani S, Ziosi P, Solaroli N, Buzzoni V, Carli M, Lucchi E, Valgimigli L, Baratto G, Manfredini L. Determination of antioxidant efficacy of cosmetic formulations by non-invasive measurement. Skin Res Technol, 2003; 9(3): 245–253.*
46. *Spaniter AH , Shahidi F, Paraliment TH , Mussinan C, Ho C , Contis ET . Food flavors and chemistry –Advances of the new millanium , Royal Society of Chemistry , Cambridge ,UK , 2001, p.567.*
47. *Pegg RB , Amarowicz R , Naczk M . Phenolic compounds in food and natural health product, American Chemical Society, 2005; p 67.*
48. *Giada MDLR, Mancini-Filho J. Antioxidant capacity of the striped sunflower (Helianthus annuus L.) seed extracts evaluated by three in vitro methods .International J. Food Sci. Nutrition, 2009; 60(5): 395–401.*
49. *Kumar S, Maheshwari KK, Singh V. Protective effects of Punica granatum seeds extract against aging and scopolamine induced cognitive impairments in mice. Afr. J. Trad. CAM., 2009; 6 (1): 49–56.*
50. *Shalaby NMM, Maghraby AS, El-Hagrassy AM. Effect of Daucus carota var. boissieri extracts on immune response of Schistosoma mansoni infected mice.Folia Microbiologica, 1990; 44(4): 441-448.*
51. *Koksal E, Gulcin I. Antioxidant Activity of Cauliflower (Brassica oleracea L.). Turk. J. Agric. For., 2008; 32: 65-78.*
52. *Dureja H. Kaushik D, Gupta M, Kumar V, LatherV. Cosmeceuticals: An emerging concept. Indian J. Pharmacol. 2005; 37(3): 155-159.*
53. *Kaleem M, Asif M, Ahmed QU, Bano B. Antidiabetic and antioxidant activity of Annona squamosa extract in streptozotocin-induced diabetic rats. Singapore Med. J., 2006; 47(8): 670-675.*
54. *Fonseca AM, Bizerra AMC, Souza JSN, Monte FJ , Oliveira MCF, Mattos MC, Cordell GA, Braz-Filho R, Lemos TLG. Constituents and antioxidant activity of two varieties of coconut water (Cocos nucifera L.). Braz J. Pharmacog., 2009; 19(1B): 193-198.*
55. *Choi J, Byun D. Studies of anti-aging action of Garlic, Allium sativum L.(I). Comparative study of Garlic and Ginseng compounds on anti-aging action. Kor Biochem. J., 1986; 19(2): 140-146.*
56. *Saxena S. Glycyrrhiza glabra-Medicine over the millennium. Nat. Prod. Rad., 2005; 4(5): 358-367.*
57. *Soon YY, Tan BKH. Evaluation of the hypoglycemic and antioxidant activities of Morinda officinalis in streptozotocin-induced diabetic rats. Singapore Med. J., 2002; 43: 077-085.*
58. *Srvidya AR, Yadev AK, Dhanbal SP. Antioxidant and antimicrobial activity of rhizome of Curcuma aromatica and Curcuma zeodaria. Arch. Pharm. Sci. Res., 2002; 1 (1): 14-19.*
59. *Patil SM, Kadam VJ, Ghosh R. In vitro antioxidant activity of methanolic extract of stem bark of Gmelina arborea roxb. (Verbenaceae). Intern. J. Pharm. Tech Res., 2009; 1(4): 1480-1484.*
60. *Madeven S, Par Y. Multifaceted therapeutic benefits of Ginkgo biloba L.: chemistry, efficacy, safety, and uses. J. Food Sci., 2008; 73(1): 14-19.*