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Review Article

Hen egg yolk oil: A potential source of bioavailable lutein and zeaxanthin for skin and sun protection

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ABSTRACT

Ultraviolet radiation is the most harmful of electromagnetic spectrum causing deleterious effects on human skin which are responsible for severe dermatological conditions ranging from tanning, epidermal thickening, erythema, photoaging, immune suppression and skin cancers. The use of sunscreens has become a prerequisite to prevent skin from the detrimental effects of ultraviolet radiations. The adverse effects of synthetic agents is shifting the mindset of the consumer towards the use of natural sources due to their antioxidant properties. One such natural agent reported to be augmented with antioxidants is egg oil, extracted from the yolk of avian eggs. Egg yolk oil, obtained by cold extraction, is a source of phospholipids, triglycerides, cholesterol and similar compounds which resemble the cell membrane in its constitution. Its unique properties of wound healing, burn healing and anti-inflammation has already been established. Egg oil is therefore now being explored as a skin and sunprotectant mainly because it contains abundant lipids and enriched with antioxidant molecules such as *lutein* and *zeaxanthin*. This review article discusses the extraction methods, constituents, dermatological applications, commercial sources and patents signifying the tremendous potential of egg oil.

Keywords: sunprotection, natural, egg oil, lutein, zeaxanthin, photoaging, antioxidant.

INTRODUCTION

The electromagnetic spectrum ranges from short wavelength cosmic rays to high wavelength radio waves. Amongst these, ultraviolet (UV) radiation consists of three distinct bands with different wavelengths. Although UV-C is filtered by ozone layer, UV-A and UV-B are responsible for sunburn to human skin [1]. Acute response to UV exposure includes tanning, epidermal thickening and erythema[2]. Chronic exposure to UV causes photoaging [3] immunosuppression and carcinogenesis.

Photo-exposure induces series of molecular and cellular changes that trigger a fast and dynamic disorder in the skin[3]. The various structural and functional changes include increase in thickness of epidermis, stratum corneum layers, massive increase in elastic fibres with increased lysozyme, cleavage of collagen and wrinkle formation[4]. UVB radiations are responsible for damage to the lipid barrier whereas UVA is reported to enhance the effect of UVB on the epidermis[5].

UV radiation causes oxidative damage which contributes to inflammation, gene mutation and immunosuppression. All these changes lead to carcinogenesis. The International Agency for Research on Cancer (IARC) has established UV rays as a human carcinogen[6]. The form of exposure to ultraviolet radiation plays a significant role in degree and risk of cancer developed. Intermittent ultraviolet exposure causes cutaneous malignant melanoma and basal cell cancer while chronic exposure is responsible for squamous cell cancer. Melanin granules in the epidermal cells of the skin is said to possess an SPF of 4, but if the exposure is for a longer time, it may not be possible to protect the skin from photo damage. Therefore, the use of sunscreens has become a requisite to prevent skin from harmful ultraviolet radiations. Though sunprotection measures like umbrella, clothes, sunglasses have always been suggested but topical formulations like creams and lotions for extemporaneous and instant application are popular due to convenience and ease of application.

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French chemist Eugène Schueller, founder of L'Oreal, is reportedly the first person to introduce sunscreen products commercially in the year 1936[7]. Since then, there has been a considerable progress in the field of sunscreens and the market is flooded with sunscreens in various form like creams, lotions, gels, sticks, etc.

The performance and efficacy of these products is gauged by their SPF value. SPF or the "Sun Protection Factor" can be defined as the numerical ratio between the minimal erythemal dose (MED) of sunscreen-protected skin, applied in the amount of $2mg/cm^2$ and the minimal erythemal dose (MED) of unprotected skin[8]. Mathematically it can be expressed by the following equation:

SPF= MED Protected/MED Unprotected

Sunscreen agents are broadly classified as physical and chemical sunscreens. Physical or inorganic sunscreens act by reflecting or scattering UV rays while chemical or organic sunscreen absorbs them[6]. A list of sunscreen agents approved by USFDA is provided in Table 1. Nevertheless, all of them claim to be highly sun protective and safe. However, the studies carried out by various researchers have reported systemic and topical toxicities of these agents. Some of them are tabulated in Table 2.

The planet is filled with people of different skin phototypes [9] and hence there could be no ideal product which could satisfy all of them[Table 3]. However, the inclination towards natural products is gaining momentum not only due to the fact that they are from natural origin or less irritant but also because they provide holistic benefits.

Specifically, certain classes of compounds like flavonoids, carotenoids and terpenoids from natural sources are rich in anti oxidative protective network[10] for example, aloe vera, [11]tomato,[12] pomegranate,[13]grapes,[14] cucumber,[11] green tea,[15] almond,[16] *etc.*

Antioxidants are responsible for reducing the damage caused by free radicals, thus avoiding damage at the cellular level. They also help to inhibit inflammation and offer protection against photo-damage and photocarcinogenesis. These antioxidant supplements can potentially boost the body's natural reserve and neutralize Reactive Oxygen Species (ROS) from intrinsic sources (e.g., cellular metabolism) and extrinsic factors (e.g., UV damage and environmental pollution). They either inhibit generation of ROS or quench the formed free radicals.[Figure 1] Besides this, the fixed and essential oils also contribute additional ';l properties like emolliency, occlusiveness and nourishment to the skin.

In case of chronic exposure to UV rays, oxidative stress is induced in the cells of epidermis and dermis due to the production of reactive oxygen species like '*singlet molecular oxygen*' and '*peroxy radicals*'. It is now established that carotenoids such as lutein and zeaxanthin react with these free radicals and nullify their effects[17].

Natural oils and sunprotection: Fats and fatty acids present in fixed oils and essential oils have been used topically from time immemorial as emollients, protectants and occlusives. These oils also possess remarkable skin penetrating power. As compared to oils obtained from petrochemical industries, oils extracted from seeds of fruits and vegetables are light, low in viscosity and allows skin to breathe[18]. Rich content of tocopherols, carotenoids and essential fatty acids in these oils make them highly valuable as natural sunprotectants. Oils from almond, coconut, cottonseed, olive, peanut, sesame, soyabean have been reported to possess a considerable SPF value too.

Shea butter, [19] jojoba oil, [20] borage oil,[11] and fish oil[21] have also been used in prevention of photoaging due to their antioxidant constituents.
The quest to add new but well documented sources of natural sunprotective agents has lead to the discovery of oil extracted from avian eggs (duck,fowl,hen,*etc*.). Being rich in bioavailable lutein and zeaxanthin, hen egg oil stands high in merit, especially in topical formulations meant to treat inflammation and photodamaged skin conditions. Hen eggs obtained from *Gallus gallus domesticus* are sources of protein, fats and micronutrients that play an important role in basic nutrition[22]. It contains a variety of bioactive compounds that can influence pro- and anti-inflammatory pathways[23]. Egg white and yolk, both contain numerous compounds with antioxidant activities, namely *ovalbumin, ovotransferrin, phosvitin*, phospholipids, vitamin E, vitamin A, selenium, and carotenoids [22]. The presence of more phospholipids and saturated fatty acids make egg yolk a very good antioxidant probably due to the presence of many physiologically active components such as lutein, *zeaxanthin* lysozyme, *sialic acid*, etc. Bioavailability of egg carotenoids is considered to be superior as compared to those from green leafy vegetables due to their increased solubilization in yolk lipids. This makes egg a unique and important carrier of bioactive carotenoids as reported by Chung *et a.*[24].

Hen Egg Yolk Oil: Source of Lutein and Zeaxanthin: Hen egg yolk oil also known as chicken egg oil, ovum oil or egg oil has been used in traditional cosmetics since time immemorial and is an established source of phospholipids, triglycerides and cholesterol. It is a potential source of lutein *and zeaxanthin* too whose antioxidant property is well known [22]. Both dihydroxy-carotenoids with the ionone ring systems substituted at both 3 and 3' carbon[25]. The presence of free hydroxyl group at each end of these molecules provides them unique biochemical properties [Figure 2]. They play an active role in the scavenging of two major ROS *viz. singlet molecular oxygen* and *peroxy radicals* and are effective deactivators of electronically excited sensitizer molecules responsible for the generation of radicals and singlet oxygen[26].

Procurement of Egg oil: Egg oil is obtained from yolk of avian eggs and they have been of interest to researchers from time to time. Hen eggs are preferred over other avian eggs in view of their low cost and ready availability. The quality of egg can also be modified by dietary components fed to hen. Some of the methods of extraction of egg oil from egg yolk are described below:

Heating method: Weaver B Cooper patented a method of egg oil extraction for the first time in 1950. He heated the yolk portion of hard boiled eggs with a fat as a starter until a dark brown liquid of low viscosity was obtained[27].

Solvent Extraction method: Since heating method lead to loss of thermo labile constituents present in egg oil, *liquid- liquid* extraction method was adopted by Larsen and Frowning in 1980. The crude oil fraction obtained was degummed, refined and bleached. They also recommended improvement of refinement techniques so that the extraction could be done at a commercial scale[28]. Warren *et al* modified this procedure in 1988 by extracting the lipid components from spray dried egg yolks using a mixture of *hexane: isopropanol* and *chloroform: methanol* (2:1). They concluded that hexane removed less cholesterol and pigment than polar solvents [29]. The extraction process was futher improvised by Werner C Nawrocki in 1997 in which he claimed high purity egg oil suitable to be used for treating skin burns, including sunburn, and for skin regeneration [30]. Aleksandrs Kovalcuks *et al* further developed this process by using 2-propanol/hexane to give a better yield [31]. Simultaneously, a novel process was invented in 1991 by Jeong S Sim for the separation of different fractions of fresh liquid egg yolk such as protein, lecithin and neutral egg oil [32].

Supercritical Fluid Extraction: Various fractions of egg yolk such as cholesterol and phospholipids have also been extracted and patented using supercritical fluid extraction method. The reported method involved treating egg yolk with a vegetable oil, homogenizing the mixture and then extracting the homogenate with supercritical carbon dioxide at an extraction pressure between 2,000 and 4,500 psig and a temperature between 31° C. and 45° C[33]. This process proved to be faster, safer and economical. Amongst the various methods, solvent extraction method is the most widely used method. [Figure 3] Egg oil is available in market under brand names of OLEOVA, (VAV Life Sciences),charismon©. etc.[Table 5] A brief description of patents regarding extraction and use of egg oil is given [Table 6].

Skin and sun protective applications of egg oil: Egg oil being rich in cholesterol, triglycerides, carotenoids, tocopherols, phospholipids and other valuable components, has been exalted for its emollient, wound healing, anti-inflammatory, antiaging, antimicrobial and anti rachitic activity by various research groups.

Emollient action: Egg oil, being rich in cholesterol has an ability to nourish and moisturize the skin and hair. As the oil is protein-free, the cholesterol is readily absorbed into the skin and is suitable for those who are allergic to egg proteins. It has also been used to formulate cosmetic emulsions like hand creams, body creams and massage creams, *etc*. when added in a range of 0.3 to 0.4% by weight[34].

Burns and wound healing: Burn injuries are one of the major causes of death and disability in the world and hence a local wound healing medication which can promote re-epithelialisation would always be appreciated. The egg oil seems excellent in healing process as proved by a research carried out by Rategar *et al.* Egg oil was applied topically to burnt skin of the animal which showed abundant re-epithelialization without tissue scar in comparison to the animals treated with silver sulphadiazine [35] . It has also been patented as a 'burn healer' by Carol J. Burg for the treatment of second and third degree burns to human skin[36].

Another research study carried out by Hahn *et al* cites the wound healing potential of charismon©, a branded egg oil[37]. They studied the effects of egg oil on a variety of physiological reactions in cells. HaCaT-cells (immortalized human keratinocytes), human umbilical vein endothelial cells in culture (HUVEC), peripheral blood mononuclear lym-phocytes (PBML) and a full thickness human skin model (FTSM) were used to study the cellular

responses. The main objective of their study was to see the influence of egg-oil on cell migration and proliferation, mitochondrial membrane potential, reactive oxygen (ROS) production and IL-8 production. According to them, egg oil promoted wound healing by re-epithelialisation and some other interlinked reactions. They also reported that egg oil containing toothpastes are available for the relief of gum inflammation and bleeding and egg oil containing ointments for healing of ulcers, scar formation and burn wound healing.

Analgesic and anti-inflammatory activity: Inflammation is purported to eliminate the initial cause of cell injury, clear out necrotic cells and tissues damaged from the original insult and the inflammatory process, and to initiate tissue repair. The cell injury can result from irritant or pathogen. Sunburn can also cause skin inflammation primarily by ROS which is responsible for cell death via DNA damage, necrosis and apoptosis. Egg oil modulated photosensitivity was studied by Hahn *et al* using full thickness human skin model (FTSM)[37]. They observed that the cell section which was treated with egg oil had normal epidermal cells with usual nuclei even after UV irradiation as compared to FTSMs without egg oil application, which showed pycnotic nuclei. *Pycnosis* is an irreversible condensation of chromatin in the nucleus of a cell undergoing necrosis and apoptosis.

Egg oil is also reported to possess significant analgesic properties and has been recommended in inflammatory joint pain conditions. In a study conducted by Mahmoudi *et al* the oil extracted from duck egg and hen egg showed significant anti-inflammatory activity at 100-300 mg/kg as compared to controls ($p < 0.001$)[38]. These oils demonstrated analgesic and anti-inflammatory activity, possibly due to the presence of *choline* since its presence reduced inflammatory markers by 20%. The presence of palmitoylethanolamide in phospholipid fraction of egg yolk can also be a contributing factor in reducing inflammation[39].

Other indications: Psoriasis is a chronic inflammatory skin disorder that has a hereditary basis for susceptibility along with environmental factors such as trauma, infections *etc*[40]. A patent filed in 1989 by Mohamed Abdessalam Yacobi, a qualified physician claimed the skin beneficial effects of a formulation containing egg oil along with sea salt, attar of roses and chalkatte in patients suffering from psoriasis [41]. He applied this formulation to the affected skin parts. In all the clinical studies carried out by him, the inventor noticed disappearance of hardened epidermis and itching within 2 days of application and subsequent normalisation of the affected skin.

Egg oil is also reported to be helpful in skin aging (improvisation of skin texture and wrinkle formation delay) using a formulation on face, traditionally known as "crème du ciel" and containing 4.5% of this oil[37]. This activity of egg oil can be attributed to the reduction of inflammatory processes and ROS production, as observed by various qualitative changes in skin parameters like moisture, surface lipids, elasticity, lipid peroxidation and photoprotection.

Rickets, a disease in which the bone tissue doesn't properly mineralize, leading to soft bones and skeletal deformities is associated with Vitamin D deficiency [42]. In a primeval study of 1934, an attempt to elucidate and compare the antirachitic efficacy of olive oil, egg oil and fatty acids of butter and lard was made by Stanisław Kazimierz Kon and Roland Gordon Booth[43]. Though they claimed egg oil as probably the most concentrated source of vitamin D activity, any clinical data in this regard would be a ray of hope for vitamin D deficient patients.

RESULT AND DISCUSSION

Several organic and inorganic agents have been used to prevent the skin from deleterious effects of ultraviolet radiations of sun. These agents are also associated with various adverse effects which have shifted the paradigm to natural agents which are rich in antioxidants. Boosting the antioxidant system of the skin with the help of natural agents is a significant approach for reducing UV induced skin damage. One such spagyric agent discussed in this paper is egg oil which is derived from egg of hen.

Egg oil is a rich source of phospholipids, triglycerides, cholesterol and resembles the constituents of a biological membrane. It is also a good carrier for sunprotective agents where carotenoids such as lutein and zeaxanthin are stabilized with emollients. Additionally, the presence of phosvitin, and free aromatic amino acids make it a very good antioxidant. Being protein free, it is a safer product for the patients allergic to egg products.

The presence of cholesterol makes it a very good emollient when used in the concentration of 0.3-0.4%.It has tremendous applications in inflammation related skin conditions such as wound healing, burns, psoriasis *etc.* due its involvement in re epithelialisation. Studies by various researchers and their published results

provide a compelling explanation to unravel a newer, safer antioxidant rich compound from natural source.

Although clinical trials of egg oil are still going on by some producers of this oil, yet it can be used safely, being edible and natural in origin. An attempt was made by the authors to extract egg oil in the laboratory and determine its SPF[44]. It can further be incorporated in various topical formulations and delivery systems such as liposomes and nanoparticles.

The manufacturers, researchers and dermatologists should all come together and develop some commercially viable safe and effective topical products enriched with egg oil for the benefits of patients suffering from skin disorders.

Conflict of Interest: The authors have no conflict of interest.

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Table 1: FDA Approved Sunscreen Agents[44]

Sunscreen Agent	Permissible limit (%)
Organic Agents	
PABA	Upto 15%
Avobenzone	3%
Cinoxate	3%
Dioxybenzone.	Up to 3%
Homosalate.	up to 15%
Menthyl anthranilate.	up to 5 percent
Octocrylene.	up to 10 percent
Octyl methoxycinnamate.	up to 7.5 percent
Octyl salicylate.	up to 5 percent
Oxybenzone.	up to 6 percent
Padimate O.	up to 8 percent
Phenylbenzimidazole sulfonic acid.	up to 4 percent
Sulisobenzone.	up to 10 percent
Trolamine salicylate	up to 12 percent
Inorganic Agents.	
Zinc oxide	up to 25 percent.
Titanium Dioxide	up to 25 percent.

Table 2: Toxicity associated with sunscreen agents

S.No.	Toxicity	Reference
1.	Photodegradation of the sunscreen agent	[45]
2.	Endocrine disruptive properties of the chemical sunscreen agents	[46]
3	Clown like effect with higher concentration of physical sunscreens	[47]
4	Photogenotoxicity associated with nanosized physical sunscreen	[47]
5	Allergic contact dermatitis caused by PABA derivatives	[48]
6	Higher risk of melanoma associated with the use of sunscreens	[49]
7	Chemical oxidation and DNA damage caused by inorganic sunscreen agent	[50]
8	Increased ROS production upon penetration of organic sunscreens	[51]

Table 3: Fitzpatrick skin phototypes[9]

Skin Type	Sunburn and tanning history
I	**Burns easily, never tans**
II	**Burns easily, tans minimally with difficulty**
III	**Burns moderately, tans moderately and uniformly**
IV	**Burns minimally, tans moderately and easily**
V	**Rarely burns, tans profusely**
VI	**Never burns tans profusely**

Table 4: SPF values of natural oils[18]

S.No.	Oil	Source	SPF
1	Olive oil	Fruit of Olea europaea	7.5
2	Coconut oil	Kernel of Cocos nucifera	7.1
3	Castor oil	Seeds of Ricinus communis	5.6
4	Almond Oil	Fruit of Prunus amygdalus,	4.6
5	Mustard Oil	Mustard seeds	2.1
6	Sesame oil	Sesame seeds	1.7

Table 5: Egg oil Specifications

Synonyms: Egg Yolk Oil, Ovum Oil, Hen Egg Yolk Oil)
CAS NO.: 8001-17-0,
INCI Name: Egg oil
BRAND NAMES: Charismon©,Oleova

PHYSICOCHEMICAL PROPERTIES	COMPOSITION OF EGG OIL
Appearance: Yellow coloured hazy liquid **Consistency**:Viscous Liquid,thickened semisolid at 25^0c **Odour**:Mild characteristic odour of egg **Refractive Index**:1.46-.148 **Flash Point**:>80^0c **Solubility in Water:** Insoluble **Specific Gravity**: 0.80-0.85.	**Moisture** 1% Max **Free Fatty Acids** 1% Max **Triglycerides** 92% Min **Phospholipids** 1% Max **Cholesterol** 4% Max **Moisture** 1.5% Max **Lutein and Zeaxanthin**

Table 6: List of Patents on egg oil extraction and applications

S.NO.	Patent No.	Publication year	Patentee	Claim as taken from respective patent	Reference
1.	US 2555731 A	1951	Weaver B cooper	Method of obtaining a new oil product from the yolks of eggs which is highly beneficial as a healing medicant for external use.	**[27]**
2.	US4219544A	1980	Carol J. Burg	Method of treatment of burns using topical application of egg oil ointment wherein egg oil is extracted by heat treatment of egg.	**[36]**
3.	US4219585	1980	Nancy I. Herring	An efficient simplified process for extracting the maximum amount of unadulterated, sterilized and medically pure egg oil from egg yolks by use only of heat.	**[52]**
4.	US 4364930 A	1982	Jacqueline Griat, et al	Composition in the form of stable emulsion for cosmetic ns pharmaceutical use composed of (1) mono- or di-alkyl carboxylates of α-methyl glucoside, or a mixture thereof and (2) mono- or di-alkyl carboxylates of α-methyl glucoside polyoxyethylenated with 10-30 moles of ethylene oxide, or a mixture thereof, the said alkyl moiety of each being linear or branched and having from 11-21 carbon atoms, (ii) lecithin, (iii) egg yolk oil, and (iv) a polyacrylic type polymer.	**[34]**
5.	US 5028449	1991	Hatanaka Hiroji H	Egg oil from dried yolks, dietary supplement.	**[52]**

6.	WO 1991003946 A1	1991	Jeong S Sim	A novel process for the separation of fresh liquid egg yolk into a yolk protein fraction, neutral egg oil fraction and an egg lecithin fraction.	**[32]**
7.	WO199201271 9 A1	1992	Mohamed Abdessala m Yacobi	Method of treatment of psoriasis using an egg oil product wherein egg of chicken turtle duck etc have been used for oil extraction.	**[41]**
8.	US5670175 A	1997	Warner C. Nawrocki	A process for the preparation of an ultrapure egg oil which can be obtained from avian or reptilian egg yolk by solvent extraction method.	**[30]**

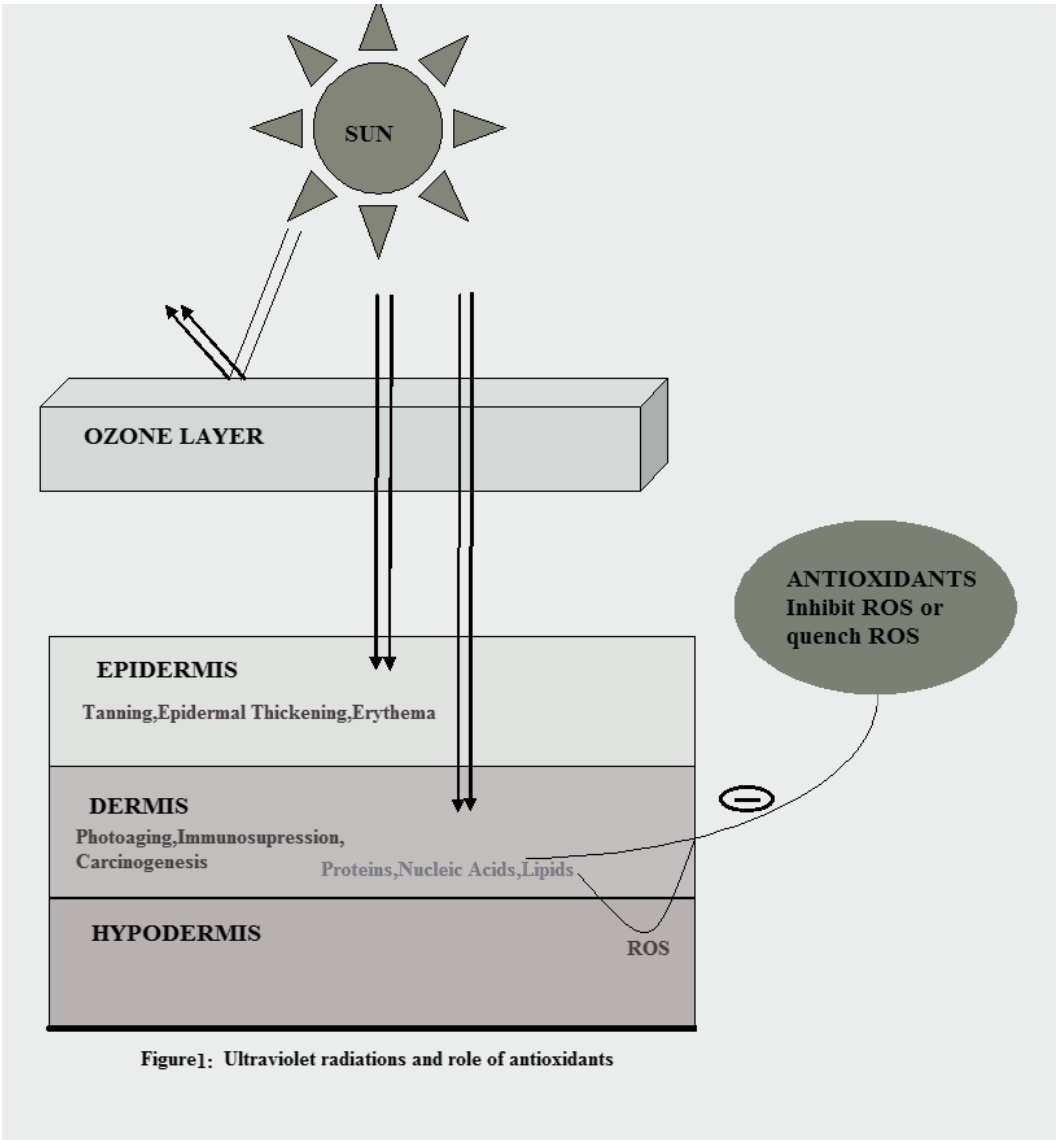

Figure1: Ultraviolet radiations and role of antioxidants

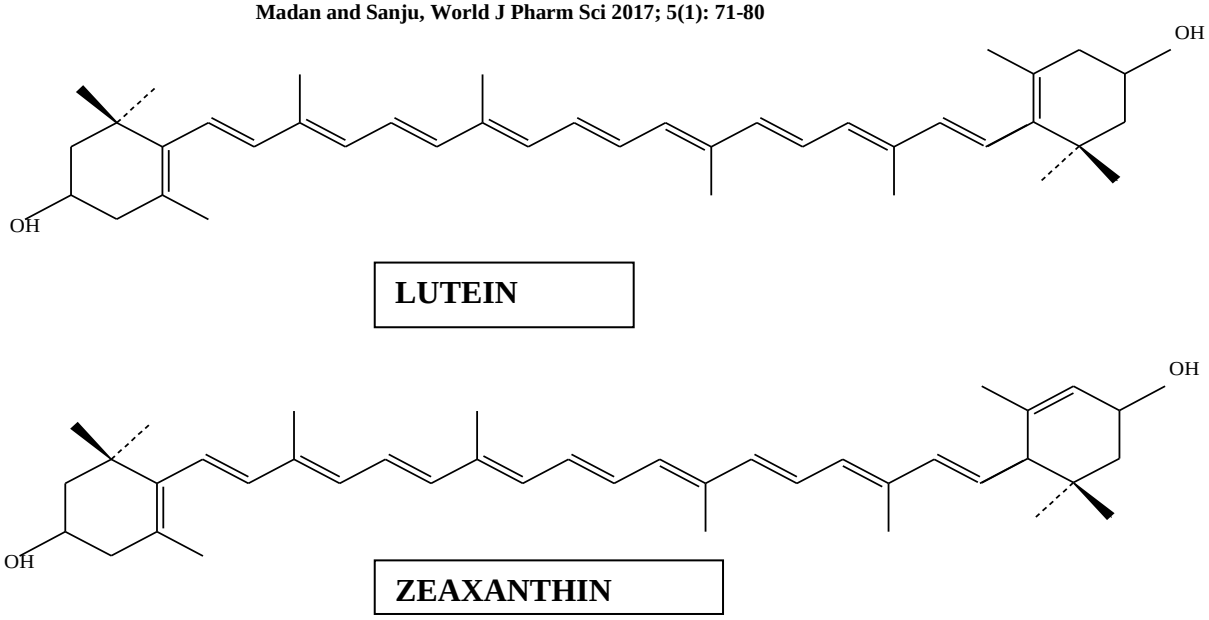

Figure 2: Structure of Carotenoids in egg oil

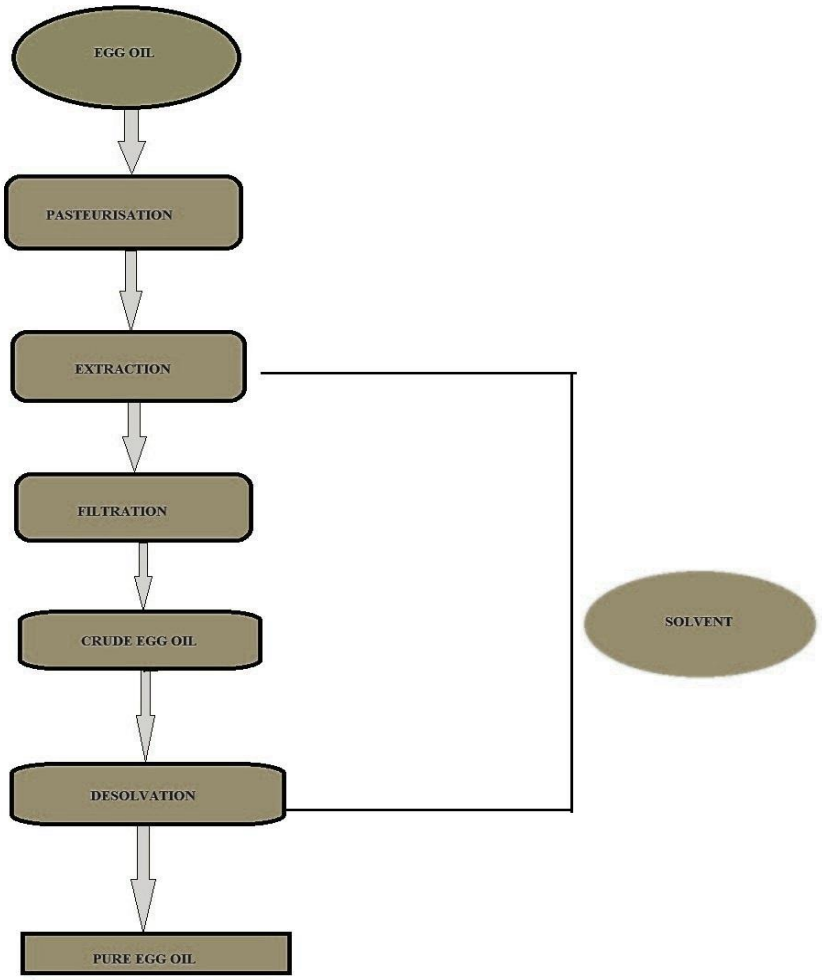

Figure 3: Solvent Extraction of egg oil

REFERENCES

1. Rai R, Srinivas CR. Photoprotection. Indian J Dermatol Venereol leprol. 2007;73(2):73–9.
2. Council on Scientific Affiairs. Harmful Effects of Ultraviolet Radiation. Journal of the American Medical Association. 1989. p. 380–4.
3. Ramos-e-Silva M, Celem LR, Ramos-e-Silva S, Fucci-da-Costa AP. Anti-aging cosmetics: Facts and controversies. Clin Dermatol. Elsevier Inc.; 2013;31(6):750–8.
4. Kaur a, Thatai P, Sapra B. Need of UV protection and evaluation of efficacy of sunscreens. J Cosmet Sci. 2014;65(5):315–45.
5. Lodyga M, Polan a, Skotarczak K, Mazur M, Adamski Z. Photoprotection : facts and controversies. 2015;98–112.
6. Gallagher RP1, Lee TK, Bajdik CD BM. Ultraviolet Radiation. p. 51–68.
7. Adam S. Aldahan, Vidhi V. Shah, Stephanie Mlacker KN. The history of sunscreen. JAMA Dermatol 2015;151(12):AB34.
8. Schalka S, Reis VMS Dos. Sun protection factor: meaning and controversies. An Bras Dermatol. 2011;86(3):507–15.
9. Sachdeva S. Fitzpatrick skin typing: applications in dermatology. Indian J Dermatol Venereol Leprol. 2009;75(1):93–6.
10. Korać R, Khambholja K. Potential of herbs in skin protection from ultraviolet radiation. Pharmacognosy Reviews. 2011. p. 164.
11. Anitha T. Medicinal plants used in skin protection. Asian J Pharm Clin Res. 2012;5:40–3.
12. Stahl W, Heinrich U, Aust O, Tronnier H, Sies H. Lycopene-rich products and dietary photoprotection. Photochem Photobiol Sci 2006;5(2):238–42.
13. Arpita Basu KP. Pomegranate juice: a heart-healthy fruit juice. Nutr Rev. 2008;67(1):49–56.
14. Balakrishnan KP, Narayanaswamy N. Botanicals as sunscreens: Their role in the prevention of photoaging and skin cancer. Int J Res Cosmet Sci. 2011;1(1):1–12.
15. Yusuf N1, Irby C, Katiyar SK EC. Polyphenols., Photoprotective effects of green tea. Photodermatol Photoimmunol Photomed. 2007;23(1):48–56.
16. Wijeratne SSK, Abou-Zaid MM, Shahidi F. Antioxidant polyphenols in almond and its coproducts. J Agric Food Chem . 2006;54(2):312–8.
17. Junji Terao YM and NB. Singlet molecular oxygen_quenching activity of carotenoids: relevance to protection of the skin from photoaging. J Clin Biochem Nutr 57–62. 2011;48(1):57–62.
18. Kaur CD, Saraf S. In vitro sun protection factor determination of herbal oils used in cosmetics. Pharmacognosy research. 2010. p. 22–5.
19. Honfo FG, Akissoe N, Linnemann AR, Soumanou M, Van Boekel M a JS. Nutritional composition of shea products and chemical properties of shea butter: a review. Crit Rev Food Sci Nutr 2014;54(5):673–86.
20. Pazyar N, Yaghoobi R, Ghassemi MR, Kazerouni a, Rafeie E, Jamshydian N. Jojoba in dermatology: A succinct review Giornale Italiano di Dermatologia e Venereologia. 2013. p. 687–91.
21. Chen AC, Damian DL, Halliday GM. Oral and systemic photoprotection. Photodermatol Photoimmunol Photomed 2013;30(2-3):102–11.
22. Nimalaratne C, Wu J. Hen Egg as an Antioxidant Food Commodity: A Review Nutrients. 2015. p. 8274–93.
23. Andersen CJ. Bioactive Egg Components and Inflammation. 2015. p. 7889–913.
24. Chung H-Y, Rasmussen HM, Johnson EJ. Lutein bioavailability is higher from lutein-enriched eggs than from supplements and spinach in men. J Nutr. 2004;134(8):1887–93.
25. Rao a. V., Rao LG. Carotenoids and human health. Pharmacol Res. 2007;55(3):207–16.
26. Jackson H, Braun CL, Ernst H. The chemistry of novel xanthophyll carotenoids. Am J Cardiol 2008;101(10A):50D – 57D.
27. Cooper WB. Oil produced from eggs. US 2555731 A. 1951;
28. Larsen JE, Froning GW. Extraction and Processing of Various Components from Egg Yolk. Poultry Science. 1981. p. 160–7.
29. M. W. Warren HGB and DRD. Solvent Extraction of lipid components from egg yolk solids. JAOCS. 1988;65(7):1136–7.
30. Nawrocki WC. Process for obtaining Ultrapure egg oil and its use. US5670175. 1997;sep 23,1997.
31. Kovalcuks A, Duma M, Technology F. Solvent Extraction of Egg Oil From Liquid Egg Yolk. 2014;253–6.
32. Sim JS. Extraction of fresh liquid egg yolk. WO 1991003946 A1. 1991;
33. Gideon Zeidler, Gonca Pasin AJK. Supercritical fluid extraction of cholesterol from liquid egg yolk. US5514401 A. 1996;
34. Jacqueline Griat, Arlette Zabotto CK. cosmetic or pharmaceutical compositions in the form of stable oil-in-water emulsions. US 4364930. 1982;
35. Rastegar F, Azarpira N, Amiri M, Azarpira a. The Effect of Egg Yolk Oil in the Healing of Third Degree Burn Wound in Rats. Iranian Red Crescent Medical Journal. 2011. p. 739–43.
36. Burg CJ. Method for treating burns using an egg yolk oil. US 4219544. 1980;
37. Bereiter-Hahn J, Bernd A, Beschmann H, Eberle I, Kippenberger S, Rossberg M, Strecker V ZN. Cellular responses to egg-oil (charismon©). Acta Medica 2014;57(2):41–8.
38. Mahmoudi M, Ebrahimzadeh MA. Anti-inflammatory and analgesic effects of egg yolk : a comparison between organic and machine made. Eur Rev Med pharmaacological Sci. 2013;17:472–6.
39. Hesselink JMK. Evolution in pharmacologic thinking around the natural analgesic palmitoylethanolamide: from nonspecific resistance to PPAR-α agonist and effective nutraceutical. J Pain Res 2013;6:625–34.
40. Schön MP, Boehncke W-H. Psoriasis. N Engl J Med 2005;352(18):1899–912.
41. Yacobi Mohamed Abdessalam. A method for manufacturing a medicine against psoriasis, and that medicine. WO 1992012719. 1992;
42. Kumar GT, Chugh R, Eggersdorfer M. Poor Vitamin D Status in Healthy Population in India : A Review of Current Evidence. Int J Vitam Nutr Res. 2015;85:1–17.
43. Stanislaw BY, Kon K, Booth RG. Xviii . The vitamin d activity of butter . The labile factor in butter antirachitic for the rat . The antirachitic potency of lard , Biochem J. 1934;28(1):121–30.
44. Madan K and Nanda " Exploring Egg oil as a natural sunprotective agent: An initial study" in National Conference on "Therapeutic Potential of Natural Products: Current Innovations and Future Trends" in Department of Genetics M.D University,15.03.15 (Poster Presentation-third prize).
45. Freitas JV1, Lopes NP GL. Photostability evaluation of five UV - filters , trans - resveratrol and beta - carotene in sunscreens . Eur J Pharm Sci . 2015;Oct 12;(78):79–89.
46. Krause M, Klit a, Blomberg Jensen M, Søeborg T, Frederiksen H, Schlumpf M, et al. Sunscreens: are they beneficial for health? An overview of endocrine disrupting properties of UV-filters. Int J Androl 2012;35(3):424–36.
47. Wang SQ, Tooley IR. Photoprotection in the Era of Nanotechnology. Semin Cutan Med Surg. 2011;30(4):210–3.

48. Mulliken JS, Russak JE, Rigel DS. The Effect of Sunscreen on Melanoma Risk. Dermatol Clin 2012;30(3):369–76.
49. Nohynek GJ, Schaefer H. Benefit and risk of organic ultraviolet filters. Regul Toxicol Pharmacol 2001;33(3):285–99.
50. Dunford R, Salinaro A, Cai L, Serpone N, Horikoshi S, Hidaka H, et al. Chemical oxidation and DNA damage catalysed by inorganic sunscreen ingredients. FEBS Lett Federation of European Biochemical Societies; 1997;418(1-2):87–90.
51. Klimová Z, Hojerová J, Pažoureková S. Current problems in the use of organic UV filters to protect skin from excessive sun exposure. Acta Chim Slovaca 2013;6(1):82–8.
52. Hatanaka HH. Process for the production of an egg lecithin. US 5028449 A.