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Melanin: Nature's Gift Against Skin Cancer

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Abstract

The pigment melanin is the gift of nature that protects the skin from damage to DNA caused by ultraviolet (UV) rays. The biochemistry of the process is exciting and individuals whose skin have this pigment should cherish and protect it. This article explains how melanin is produced in the body, its types and the biochemical activities that show how it shields individuals from developing skin cancer. As this knowledge is provided; the article posits that skin bleaching is an uninformed act. An expository presentation of the topic is done which is aimed at enhancing understanding of it. There is a plethora of scientific knowledge available on the beneficial properties of melanin; however this knowledge has regrettably not benefitted a good number of individuals in the public health community. Thus, this piece will hopefully raise awareness on the priceless importance of melanin and discourage acts like skin bleaching that distort its benefits.

Keywords: *Melanin; Bleaching; Skin Cancer*

INTRODUCTION

Melanin is a term used to describe a large group of related molecules responsible for many biological functions, including pigmentation of skin and hair and photoprotection of skin and eye **(1,2,3).** In humans, melanin exists in three forms: eumelanin (which is subdivided further into black and brown forms), pheomelanin, and neuromelanin. The ability of melanin to protect the skin from the effects of harmful radiations has been scientifically proven.

MELANIN SYNTHESIS

At the cellular level, eumelanin and pheomelanin are produced in various amounts in the basal layer of the epidermis within cells called melanocytes. Melanocytes are the mature forms of melanoblasts, which migrate from the neural crest following neural tube closure. As melanin is produced within melanocytes, it is packaged in small, round membrane- bound organelles called melanosomes. Melanosomes are transported from melanocytes to neighboring keratinocytes via tentacle-like dendritic processes. Melanosomes arriving in keratinocytes are positioned superficially to cell nuclei, which serves to protect from incoming ultraviolet (UV) radiation. **(4).**

In the process of skin pigmentation, melanosomes are transferred from melanocytes in the basal layer of the epidermis to overlying keratinocytes. The transfer involves a unique biological process involving organelle donation from one cell to another and is a crucial step in skin pigmentation. Individuals with defects in transfer can have markedly reduced skin melanin content. Melanosome transfer begins with attachment of melanocyte dendrites to keratinocytes followed by transfer of melanosomes through the melanocyte dendrites into the keratinocytes and finally trafficking of the melanin within keratinocytes to the supra-nuclear area of the cell **(5).** Thus, human skin colour stems from the outermost layer of the skin, the epidermis where the pigment-producing cells melanocytes are localized to produce melanin.

MELANIN AND PROTECTION FROM SKIN CANCER

Exposure to terrestrial solar UV radiation (UVR) causes skin cancer **(6),** including malignant melanoma (MM) and keratinocyte cancers [KCs; basal cell carcinoma (BCC) and squamous cell carcinoma (SCC)]. These cancers are less prevalent in people with deeply pigmented skin than in white individuals, although their prognosis is worse **(7).** In the United States, those with white skin are 70 times more likely to develop any skin cancer than those with black skin **(8).** Recent data from South Africa demonstrated a 60- and 20-fold higher incidence of BCC and SCC, respectively, in individuals with white skin compared with those with black skin **(9, 10)**. Skin color is primarily determined by epidermal melanin. HPLC has identified 9-fold more melanin content in black skin than in white skin **(11).** The rarity of cutaneous malignancy in black skin has been assumed to be a result of photoprotection by epidermal melanin, which has been reported to have a UVR absorption factor of at least 4 ex vivo **(12).**

Melanin is historically known to offer protection to the skin against harmful radiation. Direct sun exposure is one of the most aggressive factors for human skin. Sun radiation contains a range of the electromagnetic spectrum including UV light. In addition to the stratospheric ozone layer filtering the most harmful UVC, human skin contains a photoprotective pigment called melanin to protect from UVB, UVA, and blue visible light. This pigment is a redox UV-absorbing agent and functions as a shield to prevent direct UV action on the DNA of epidermal cells. In addition, melanin indirectly scavenges reactive oxygen species (ROS) formed during the UV-inducing oxidative stress on the skin **(13).** Skin is an important barrier to protect the human body from environmental stress. One of the more important factors causing this stress is sun exposure, due to the energy and free radical generating capacity of sunlight. The solar radiation on the surface of our planet comprises an ample range of electromagnetic radiation **(14).** The ultraviolet (UV) radiation is part of this electromagnetic radiation.

UV radiation constitutes about 10% of the total energetic output of the sun. The biologically active composition of the UV radiation reaching the earth has suffered some changes in the last decades due to chemical contamination and atmospheric factors (**1**4). This radiation is usually subdivided into three regions (UVA, UVB, and UVC). UVA comprises the longest wavelengths (320–380 nm), partially overlapping with the accompanying visible light, while UVB wavelengths are in the middle span (280–320 nm) and UVC comprises the shortest wavelengths (180–280 nm) with the

highest energy. Fortunately, UVC rays do not penetrate through the stratosphere since the ozone layer acts as an efficient filter to deter the very harmful effects of such radiation. **(13).**

It is noteworthy that long term exposure to UV radiations can damage the skin. Included in this potential damage to the skin are mutations that can lead to different types of skin cancer. To simplify the complexity of the mechanisms involved in these effects, UV light damages DNA by two different ways. The first one is produced through direct DNA absorption of mutagenic radiations, thereby increasing lesions called the UV "signature" (pyrimidine dimers or 6-4 photoproducts). The second mechanism is indirect, through interaction with other biochromes generating reactive oxygen species (ROS) which produce harmful cellular effects and can reach the nucleus causing oxidative DNA modifications and strand breaks (**15,16,17).** In both cases, accumulative damage of DNA can finally induce apoptosis or lead to cancer appearance [**16,18).**

There is little doubt that melanin provides the skin with protection against UV radiation and this is supported by both in vitro and in vivo studies **(19,20,21,22,23,24).** It is well recognised that dark-skinned individuals tolerate sunlight better than those with lighter skin and show a lower risk of skin cancer **(25).** One possibility is that melanin acts to remove reactive oxygen species (ROS). ROS, including hydroxyl radical, superoxide anion and hydrogen peroxide which are generated in the skin in response to UV radiation, are capable of inducing lipid peroxidation, protein modifications and DNA damage **(26).** Melanin is known to be a scavenger of radicals and reactive oxygen species **(27, 28, 29)** and it has been suggested that it possesses superoxide dismutase activity **(30, 31).** The synthesis of melanin may, in addition, serve as a free radical trap and this is supported by findings that the preferred substrate for tyrosinase, the rate limiting enzyme in the melanin pathway, is the superoxide anion rather than molecular oxygen **(32, 33).**

Another property of melanin is its capacity to bind Ca^{2+} **(34, 35, 36).** There are indications that the melanosome is actively involved in regulating Ca^{2+} homeostasis by taking up and releasing Ca^{2+} **(37).** This could have many important consequences in the melanocyte including effects on antioxidant defence. Ca^{2+} is known to have a role in antioxidant defence and there are reports that in lymphocytes and Jurkat cells, low intracellular Ca^{2+} concentrations protect against H_2O_2-induced DNA strand breaks, whereas high Ca^{2+} concentrations facilitate this type of DNA damage **(38, 39)**

MELANIN AND SKIN BLEACHING

Skin-bleaching practices, such as using skin creams and soaps to achieve a lighter skin tone, are common throughout the world and are triggered by cosmetic reasons that oftentimes have deep historical, economic, sociocultural, and psychosocial roots **(40).** It has been scientifically proven that skin bleaching or whitening agents mainly work by interfering with melanin production. For instance, hydroquinone (a commonly used agent in skin whiteners), works by decreasing melanin production **(41).**

Skin whitening agents work by reducing the presence of melanin pigment in the skin. To accomplish this, there are several possible mechanisms of action **(42):**

- Inhibition of the activity of tyrosinase: The catalytic action of tyrosinase is inhibited by the skin whitening agent.
- Inhibition of the expression or activation of tyrosinase: The anti melanogenic agent causes less tyrosinase to be generated or prevents tyrosinase from being activated to its functional form.
- Scavenging of the intermediate products of melanin synthesis.
- Preventing the transfer of melanosomes to keratinocytes.
- Directly destroying existing melanin
- Destroying melanocytes.

CONCLUSION

This article establishes the role of melanin in skin pigmentation. The pigment is responsible for dark colouration of the skin and has many benecial effects; including shielding the skin from harmful effects of UV radiation. One of such deleterious effects of UV radiation on the skin is its ability to cause different types of skin cancer on prolonged exposure.

Hence, one can rightfully conclude that melanin is nature's gift to humans to protect them from skin cancer. So, the dark skin should be seen as a priceless gift and cherished by all that have it.

FOOTNOTE

This article is a sincere attempt to present the benefits of melanin pigment which is responsible for dark colouration of the skin. The author recognizes the uniqueness and benefits of all skin colours and has no intention of promoting any against the other.

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