Sunless Tanning: A Review

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Despite rising numbers of melanoma and nonmelanoma skin cancers, many Americans continue to tan their skin and believe that a tan enhances their appearance. It is well documented that ultraviolet (UV) radiation from the sun or indoor tanning beds is linked to skin cancer and accelerated aging of the skin. In an effort to reduce exposure to UV radiation, and subsequently decrease the risk of skin cancer, some dermatologists have advocated the use of sunless tanning products.

Most sunless tanning products contain the active ingredient dihydroxyacetone (DHA). DHA tans the skin by binding to amino acids in the stratum corneum, producing covalently bound chromophobes called melanoids through a process known as the Maillard browning reaction. To decrease the adverse effects associated with UV-radiation–induced tanning, physicians must continue to advocate a safe alternative. Sunless tanning with DHA-based formulations should be recommended to patients desiring a tanned appearance.

Despite rising numbers of melanoma and nonmelanoma skin cancers, many Americans continue to tan their skin believing that they are enhancing their appearance. Throughout time, skin color has played a crucial role in individual identity, self-esteem, and character. Although tanned skin is currently considered by many to be attractive, this has not always been the case. Many ancient cultures, such as the Romans and Greeks, valued pale skin. During the 1800s, high society looked down upon people with tanned skin because a tan implied that they were outdoor laborers and of a lower class. To convey an image of upper-class status, wealthy women carried parasols and spent much of their time inside to prevent darkening of the skin.

The Industrial Revolution created more jobs in sun-protected environments. Instead of connoting lower-class status, tanned skin became a sign of financial strength, an indication that one had enough money to vacation in the sun. The popularity of a fashionable tan was epitomized by the French fashion designer Coco Chanel in 1923, when she began using tanned women in her advertisements and consequently initiated a trend that still persists today.[1,2]

As sun exposure increased during the 1920s, physicians began to voice concerns about possible risks. The US Public Health Service issued warnings about the potential dangers of excessive sunbathing. In the 1930s, ultraviolet (UV) radiation was recognized as a carcinogen; a 1935 article in the *Journal of the American Medical Association* listed sunlight as a possible cause of cancer. Further studies confirmed this hypothesis, implicating sunlight as a cause of cutaneous malignancy and accelerated photoaging.[3] However, despite the recent increase in public awareness of this association, sunbathing outdoors and indoor tanning under UV lights continue at a high rate.[4]

It is well documented that UV radiation from the sun and indoor tanning beds is linked to skin cancer and accelerated aging of the skin.[5-14] In an effort to decrease the practice of UV-radiation–induced tanning and subsequently decrease the risk of skin cancer, some dermatologists have advocated the use of sunless tanning products.[4-8,14,15] Most sunless tanning products contain the active ingredient dihydroxyacetone (DHA), a compound observed serendipitously in the 1950s to pigment the skin on contact. At that time, DHA was being administered orally in studies on glycogen storage disease.[16-18]

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BASIC SCIENCE OF SUNLESS TANNING

DHA is a 3-carbon sugar involved in carbohydrate metabolism in higher plants and animals through processes such as glycolysis and photosynthesis.[17,19-21] DHA tans the skin by binding to amino acids in the stratum corneum, producing covalently bound chromophobes called melanoids through a process known as the Maillard browning reaction.[1,8,18,20,22-24] This tanning effect is independent of light but is enhanced by UV radiation.[25]

To produce a sunless tanning product, DHA is usually added to a lotion, cream, liquid, or mousse base in concentrations ranging from 3% to 5%.[1,4,8] The intensity of the color is dependent on the concentration, thus allowing for a wide range of shades to accommodate individual preference.[8] Increasing the protein content of the stratum corneum may enhance coloring; thus, the shade achieved is dependent on the thickness of keratin as well.[1,20,26] Rougher, hyperkeratotic skin, as well as freckled and mottled skin, takes up the color at an increased intensity, resulting in coloring irregularities.[8] The brown color produced from DHA is resistant to soap and water but may be removed by sloughing of the stratum corneum, as with vigorous scrubbing.[19,20,22,24] While the pigment from DHA takes several hours to form, many products now contain water-soluble dyes that impart immediate color upon application.

CLINICAL APPLICATIONS

Dermatologists encourage sunless tanning as an alternative to UV radiation, and fortunately, sunless tanning products have advanced in cosmetic appeal over the years. More recent products create a natural golden-brown hue as opposed to the orange color that often resulted from the use of older products. In addition to DHA-based topical tanning products, sunless tanning booths using a spray-on application have increased the ease and accessibility of UV-radiation–free tanning.[4,8] In a recent study by Sheehan and Lesher,[7] the majority of individuals who have used UV-radiation indoor tanning beds in the past reported doing so less frequently as a result of sunless tanning. Another recent study associated the use of sunless tanning products with increased sun protection behavior.[27]

Other studies have explored the possibility of continued indoor tanning despite known health risks as a psychosocial phenomenon or an addictive behavior learned in adolescence.[5,6,14,28] Demko et al[14] reported that 36.8% of white female adolescents and 11.2% of white male adolescents in their study population had used indoor tanning beds at least once. Feldman et al[5] showed that UV exposure by indoor tanning beds in adolescents is a reinforcing stimulus. In addition, Zeller et al[6] reported that teenagers who begin tanning at a young age and do so frequently are more likely to have difficulty quitting. These findings are consistent with other addictive behaviors that can arise during adolescence.

Although DHA has been popularized as the browning agent in topical sunless tanning formulations, it is widely known for other uses as well. Initially, before the browning properties of DHA were discovered, this compound was used to treat diabetic coma, was administered to patients with diabetes as a glucose alternative, and was used as a tool to test for glycogen storage diseases.[17] More recently, DHA has been investigated for its potential use in skin camouflaging for patients with vitiligo. Studies by Fesq et al[26] and Suga et al[29] showed it to be both a practical and well-accepted cosmetic treatment for this form of skin depigmentation. DHA has also been used to enhance photochemotherapy in psoriasis treatment.[24]

DHA-based formulations have been found to protect the skin of patients with ultraviolet-A (UVA) sensitivity such as hereditary polymorphic light eruption, photosensitive porphyria, drug photoallergy, and actinic reticuloid.[20,30-34] Many traditional sunscreens do not protect from UV radiation in the longer UVA and visible light range.[32,35,36] DHA has a proven benefit in blocking longer UVA (320–340 nm) and visible (400–750 nm) light.[31,34] This photoprotection has been demonstrated in the laboratory as well. In 1975, Fusaro and Johnson[33] demonstrated that a combination of DHA and lawsone prevented photo-induced edema in the paws of photosensitized rats.

SAFETY

With the increasing use of DHA, physicians must consider not only its efficacy but safety issues as well. This 3-carbon sugar is a physiologic product of the body and is presumed to be nontoxic.[16,23] DHA has been used as diet supplementation in rats to investigate postprandial glycogen metabolism; no adverse effects were noted.[37] Two case reports published by Morren et al[38] documented contact allergy to DHA. However, in a reply to these case reports, Johnson and Fusaro[22] pointed out that the source and purity of DHA were not specified. Concerns have arisen about the possible mutagenic properties of DHA, and there are conflicting reports in the literature. Pham et al[39] demonstrated in 1980 that DHA is mutagenic in the *Salmonella* mutagenicity assay. More recently, Petersen et al[23] discovered DHA to induce DNA damage, cell-cycle block, and apoptosis in cultured keratinocytes. However, in another study, Petersen et al[20] reported DHA to delay UV-radiation–induced photocarcinogenesis in hairless mice. Other investigators have shown DHA to have a lack of mutagenicity or even to be antimutagenic. Akin and Marlowe[17] observed no increase in cancer in mice after application of topical DHA for 80 weeks. Furthermore,

Chan et al[40] reported that the products of the Maillard browning reaction are antimutagenic. Taken as a whole, the medical literature seems to support the safety of topical application of DHA. Safety concerns still remain with regard to the use of DHA during pregnancy and the possible theoretical risks involved in inhaling DHA or other components of the tanning solutions in spray-on booths.

CONCLUSION

Civilization has a long history of preoccupation with skin color. The golden-bronze look is seemingly attractive and one that many aspire to achieve. Therefore, the public will continue to engage in UV-radiation–induced tanning despite known health risks. To decrease the adverse effects associated with this practice, physicians must continue to advocate a safe alternative. Sunless tanning with DHA-based formulations should be recommended to patients desiring a tanned appearance. Patients should also be informed that use of sunless tanning products is not sufficient sun protection. Formulations with DHA result in a sun protection factor (SPF) of only 2 and offer no protection against ultraviolet-B light.[8,34] In addition, the SPF gained from the sunless tanning product is effective only for a short period of time, not for the duration of the artificial tan. It is recommended that patients use a traditional sunscreen with an SPF of at least 15 in conjunction with the sunless tanner.[15]

With more cosmetically appealing products now available, sunless tanning is becoming a safe alternative to the "traditional" tan. The long-term risks, if any, of consistent use of DHA in humans have not been fully elucidated. However, the compound appears to be safe. It is prudent for dermatologists to continue to recommend this alternative for skin tanning and to inform patients of the need for added SPF through the application of traditional sunscreen. Until society deems pale, nontanned skin attractive, we must continue to pursue alternatives to decrease UV-radiation–induced photocarcinogenesis.

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