The Impact of Nutritional Diet on Skin Health and Anti-Aging

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Abstract. In recent years, with the improvement of economic level, people's pursuit of quality of life and healthy lifestyle has been strengthened, and skin care has gradually received attention. The impact of diet on skin condition has become a hot topic of public concern. As the first line of defense of the human body, the skin can effectively resist ultraviolet rays, pathogens and chemicals, but with the increase of age and the occurrence of certain diseases, its barrier function is affected to varying degrees. Adequate nutrient intake and healthy eating habits are essential for skin health, while unhealthy eating habits may have a negative impact on the skin. In addition, skin health is also affected by the "skin-gut axis". Poor eating habits and stress can lead to an imbalance of intestinal flora, which can cause skin diseases. According to the World Health Organization, global healthy life expectancy has increased in the past two decades, and improving the quality of life of the elderly and slowing down the aging process have become important issues for the international community. This article focuses on the impact of a healthy diet on skin health, especially closely related to anti-aging. Studies have shown that nutrients such as plant extracts, vitamins, and antioxidants are beneficial to the skin, and the Mediterranean diet pattern is widely recognized as a healthy diet and has a positive effect on the skin. Although the diversity of dietary interventions is complex, the long-term effects of a nutritious diet on health need to be further studied.

Keywords: Skin care, nutrition, dietary pattern.

1. Introduction

In recent years, with the improvement of economic level, people's pursuit of quality of life and healthy lifestyle is increasing. Among them, skin care has become more and more prominent, and the effect of diet on skin condition has gradually become a hot topic of public concern. As the first barrier of the human body, the skin can effectively defend against ultraviolet rays, pathogens, chemicals, and physical injuries. However, the barrier function of the skin is affected to varying degrees with age and the onset of certain diseases. Diet and nutrition are playing an increasingly important role as key factors in maintaining healthy skin. Maintaining adequate nutrient intake and healthy eating habits can significantly contribute to skin health; conversely, unhealthy dietary practices may be detrimental to the skin.

As an example of care for acne vulgaris, a randomized controlled trial (RCT) study showed that participants in the low glycemic load diet group had a significant advantage in facial acne improvement compared to the high glycemic load diet group [1]. In addition, skin health is influenced by the “skin-gut axis”. Factors such as poor dietary habits and stress can lead to imbalances in the gut microbiota, which can lead to skin disorders. Therefore, different dietary habits not only affect skin condition, but may also be closely related to the development of several skin-related diseases.

According to the World Health Organization's August 2, 2024 update, healthy life expectancy at birth has increased globally over the past two decades, rising by 3.57 years from 2000 to 61.9 years as of 2021, and even reaching 73.6 years in some countries. This trend indicates that improving the quality of life of the elderly and slowing down the aging process has become an important issue for the international community. This paper will focus on the impact of healthy diets on skin health, a topic that is inextricably linked to anti-aging, despite the central focus of this paper being skin health.

2. Key Nutrients and Bioactive Compounds Impacting Skin Health

This section focuses on the role of seven key classes of nutrients and bioactive compounds on skin health, including plant extracts, alkaloids, vitamins, carotenoids, antioxidants, lipids and fatty acids, collagen, and prebiotics and probiotics. Each group of nutrients is described in terms of their chemical properties and their specific effects on the skin, and their mechanisms and application values are described separately

2.1. Plant Extracts

2.1.1 Flavonoids

Flavonoids are one of the most important components of plant extracts and are widely found in fruits and vegetables. Berry fruits such as raspberries, blackberries and strawberries are an important source of polyphenols and flavonoids. Studies have shown that these compounds prevent the development of skin problems, such as seborrheic dermatitis, by reducing the inflammatory response. Flavonoids also have anti-hyperglycemic and anti-inflammatory properties that help promote skin regeneration. In addition to their ability to increase the expression of antioxidant enzymes, antiproliferative promotion of wound healing, and thus maintain normal skin function.

2.1.2 Polyphenols

Polyphenols have significant antioxidant and anti-inflammatory effects and are important in a variety of plant extracts. For example, catechins in green tea are able to reduce skin damage from UVB radiation by inhibiting UV-induced oxidative stress. They also help maintain healthy skin by enhancing DNA repair [2]. Another common polyphenol, resveratrol, found in red grape skins, exhibits antioxidant, anti-inflammatory, and antibacterial properties [3]. In addition, curcumin has also come into the spotlight for its potent anti-inflammatory and antimicrobial effects, although further validation of its specific clinical effects is needed.

2.1.3 Tannins

Widely found in plant products such as tea and coffee, tannins have a positive impact on skin health through their antioxidant properties. Tannins are effective in scavenging free radicals and slowing down the aging process of the skin. In addition, they have antimicrobial properties that help protect the skin from external aggressions.

2.2. Alkaloids

Alkaloids are another important class of active ingredients in plant extracts. They come from a wide range of sources and effects on the skin, from caffeine to nicotine, these compounds produce different effects on skin health.

2.2.1 Caffeine

Caffeine, also known as 1,3,7-trimethylxanthine, belongs to the methylxanthine group of alkaloids [4]. It is a complex of compounds that have mutagenic and also some anticarcinogenic properties There is growing evidence that consumption of caffeinated coffee reduces the risk of several types of skin cancer [5]. Also, as a central nervous stimulant with many effects on the brain, the results of three independent cohort studies have concluded that caffeinated beverages such as coffee or tea may reduce the risk of glioma in adults [6]. For dermatophytes, caffeine has been shown to inhibit their growth while altering the robustness of their cell walls, resulting in a better antifungal effect [7]. However, even though caffeine is present in coffee containing sugar or sweeteners, the sugar and sweeteners may interfere with the antioxidant effects of caffeine by generating reactive oxygen species (ROS), so it is best to consume caffeine without accompanying sugar or sweeteners to maximize the health benefits [8].

2.2.2 Other Alkaloids

For other alkaloids, it is very worth mentioning nicotine, as e-cigarettes are becoming more and more sought after, the effect of this new product on the skin is a topic well worth exploring, for example, in an experiment exposing healthy people without skin and other related diseases to nicotine smoke, the results showed that skin exposure to CS, a nicotine-containing smoke, would induces localized oxidative stress, which leads to skin barrier damage and connective tissue degradation [9].Similarly, in a nicotine exposure study for adult male guinea pigs, it was found that the mean epidermal thickness was significantly increased in the high-dose nicotine treatment group [10], whereas guinea pig skin can be found to be in the range of 65% after calculating the factor of difference from human skin, making it a better model for the permeability of human skin, which can be used for studies on human skin [11]. Nicotine ingestors, especially smokers, may contribute to the development of squamous skin plaques, also known as psoriasis [10].

2.3. Vitamins

2.3.1 Vitamin C (VC)

Vitamin C, which has anti-inflammatory and antioxidant properties, brightens skin tone, promotes wound healing, and facilitates skin regeneration. For instance, pineapple and mango is a high-quality source and according to data published by the US Department of Agriculture in 2018, 100g of mango contains about 13. 2-92.8 mg of ascorbic acid, which is also a high-quality source of vitamin C, it is beneficial for enhancing skin health.

Whereas vitamin c deficiency may lead to scurvy, a skin lesion disease that causes petechiae, ecchymosis, bleeding gums and slow healing wounds on the skin, the skin of those who are deficient in vitamin c may have enlarged hair follicles, keratinization, and other symptoms caused by impaired collagen synthesis [12].

2.3.2 Vitamin E (VE)

Vitamin E, as a fat-soluble antioxidant, prevents lipid peroxidation and protects cell membranes. The role of vitamin E is widely recognized in improving skin hydration and promoting wound healing. Vitamin E deficiency can lead to skin ulcers and interfere with normal collagen synthesis [13].

2.3.3 Additional vitamins (Vitamin D)

Vitamin D is a fat-soluble vitamin and keratinocytes are the source of vitamin d and responders to its active form, vitamin d also has a dose-dependent effect on keratinocyte proliferation and differentiation, thus providing some maintenance of the skin barrier [14].

Vitamin deficiency leads to increased inflammation and oxidative stress, which can lead to impaired skin wound healing. In a case-control study, it was found that the prevalence of atopic dermatitis may be inversely related to vitamin D levels [15].

2.4. Carotenoids and Antioxidants

Carotenoids and other antioxidants are able to slow down the skin aging process and reduce photodamage by inhibiting the production of free radicals.

2.4.1 Astaxanthin

Studies have shown that the antioxidant and anti-pollution effects of astaxanthin in krill oil at 30-5000 mg/kg are significantly stronger than those of other natural or synthetic antioxidants, and that it has a strong protective effect on the skin [16]. It can reduce the production of reactive oxygen species, decrease transepidermal water loss, and increase skin elasticity after pretreatment, thus preventing skin aging and inhibiting the risk of skin cancer [17].

2.4.2 Other carotenoids

Carotenoids provide moderate endogenous protection to the skin against UV damage to facial skin. One mechanism for this photoprotection is similar to that of sunscreen protection, in that when

sensitizing compounds such as porphyrins or riboflavins are present in the skin, they can absorb UV light and undergo oxidative stress through electronic excitation, and carotenoids can scavenge oxygen and reactive free radicals to protect the skin from oxidative damage. Another mechanism is that carotenoids can filter and absorb UV light and interfere with the expression of UV-moral genes due to their maximum absorbance at wavelengths within the visible range [18], and the concentration of carotenoids in the skin is directly correlated with the intake of fruits and vegetables, which are abundantly available in avocado, rich in enough carotenoids to provide photoprotection to the skin. The flesh of mango is also rich in carotenoids (pro-vitamin A, 3894 IU/100g), and mango has become an important dietary source of vitamin A in vitamin A-deficient areas, where intake of about 300 g of fresh ripe mango three times a day can meet and exceed 50% of the daily RE requirement [19], has been used by indigenous peoples in some regions like the Caribbean, where mango is abundant, for the treatment of ulcers and other skin ailments.

2.5. Lipids and Fatty Acids

Lipids and fatty acids play a vital role in the maintenance of skin barrier function. They can help repair and maintain healthy skin by promoting skin moisturization and reducing inflammatory responses.

2.5.1 Phospholipids

The phospholipid bilayer, present in the cell membranes of all plants and animals, is an important component beneficial to the skin, and more than 80% of the two fatty acids EPA and DHA present in krill oil have to be bound to phospholipids to synergize with skin function.

2.5.2 Omega-3 and Omega-6 Fatty Acids

Compared to trans fatty acids as well as high intake of saturated fatty acids, these fatty acids are thought to be directly related to the worsening of atopic dermatitis. In this context, polyunsaturated fatty acids, such as omega-3 and omega-6, have been shown to have anti-inflammatory properties and to be effective in reducing inflammatory skin reactions. In particular, krill oil is rich in 21.5-56.57% omega-3 polyunsaturated fatty acids, especially DHA and EPA, which have shown significant positive effects on the skin in terms of anti-aging, anti-inflammation, and promoting wound healing [17]. The intake of these fatty acids is not only essential for maintaining the healthy state of the skin, but also helps to resist skin damage caused by environmental factors. In addition, studies have found that excessive intake of processed foods containing high levels of TFAs, such as fried foods and pastries, significantly elevated the incidence of atopic dermatitis. Therefore, maintaining a good diet with moderate intake of beneficial fatty acids is important for the prevention of skin problems. Another source of potentially beneficial fats is sea buckthorn oil. Sea buckthorn oil is rich in unique unsaturated fatty acids that not only have anti-aging properties, but also promote skin wound healing and improve skin pigmentation. For example, sea buckthorn oil is rich in palmitoleic acid, which is beneficial to human sebum and effectively participates in disinfecting activities on the skin surface. As a natural antimicrobial agent, it significantly improves infections caused by Staphylococcus aureus and Acinetobacter spp. and is therefore widely used in many cosmetic products. These findings emphasize the importance of a rational intake of omega-3 and omega-6 fatty acids, providing new support for skin health.

2.6. Collagen

Collagen is one of the most abundant proteins in the body, especially in the skin, hair and bones. As we age, collagen production gradually decreases, which directly affects the appearance and health of the skin. It not only maintains the structure and elasticity of the skin, but also helps repair damaged tissues, making it vital in skin care. Supplementing collagen through diet or taking collagen supplements is increasingly becoming an effective anti-aging tool, and has been widely studied especially for enhancing skin elasticity and reducing wrinkles [20].

2.6.1 Collagen and Skin Elasticity

Collagen is a key protein in the body that maintains the health of hair, skin and bones. Decreased collagen density and dermal thickness as well as decreased synthesis and replacement of key proteins can lead to aging of the skin, increased wrinkles, and skin laxity.

2.6.2 Dietary Sources of Collagen

Studies have shown that after taking certain doses (2.5, 5 and 10g) of vegan collagen, crow's feet declined by 32.62%, 12.83% and 22.70% from baseline data on the tenth day, and by 49.94%, 50.97% and 53.16% after adhering to the 60-day period. For skin roughness also had different degrees of significant decreases, even at day 60 can reach 121.74%, 185.27% and 145.90%. Skin viscoelasticity, skin smoothness, degree of hydration, hair density etc. had different degrees of significant enhancement [21].

Meanwhile, in another study it was shown that after 84 days of comparing the two groups of oral collagen peptides and placebo (maltodextrin), the increase in skin hydration was significantly higher in the group taking collagen peptides than in the placebo group, $p=0.023$, which shows the strong evidence between collagen and skin hydration [22], which shows the beneficial effects of collagen intake on skin health.

2.7. Prebiotics and Probiotics

Prebiotics and probiotics have received a lot of attention in skin health in recent years. Not only do they affect overall health by modulating the gut microbiota, they have also been shown to have a significant effect on immune function and barrier repair in the skin. While prebiotics indirectly improve skin health by selectively promoting the growth of probiotics in the gut, probiotics can improve a wide range of skin problems through direct action on the skin microbiota. A growing body of research suggests that prebiotics and probiotics have unique potential for anti-inflammatory, whitening, and anti-aging effects [23].

2.7.1 Prebiotics

When applied directly to the skin microbiota, probiotics selectively increase the growth activity of the beneficial “normal” skin microbiota, while probiotics work with resident bacteria to produce antimicrobial peptides that eliminate pathogens and mediate the skin's immune response. Regular oral administration of Triphala, a polyphenol-rich prebiotic, has been shown to improve seborrheic dermatitis.

2.7.2 Probiotics

Probiotics have a more pronounced effect on whitening, moisturizing and anti-aging. In the treatment of atopic dermatitis, probiotics upregulate regulatory T cells and accelerate the recovery of barrier function. Decreased ceramide in the stratum corneum leads to epidermal water loss and impaired barrier function, and probiotics can increase ceramide production to enhance barrier function in acne patients [24] while probiotics may reduce acne inflammation by decreasing the release of inflammatory cytokines and the aggregation of CD8 cells to activate regulatory T-cells.

3. Dietary Patterns and Skin Health

3.1. Mediterranean Diet

The Mediterranean Diet is considered one of the healthiest dietary patterns in the world today. A 2023 AHA statement highlights the Mediterranean Diet as one of the top four dietary patterns aligned with its guidelines. These diets are rich in vegetables, fruits, whole grains, and plant-based proteins. The Mediterranean Diet also emphasizes omega-3-rich fatty fish, known for cardiovascular benefits.

A study in the European Heart Journal links both unprocessed and processed red meat to higher risks of cardiovascular disease (CVD) and diabetes, while the Mediterranean Diet's limited red meat intake supports its health benefits [25].

The study showed that adequate intake of yellow and green vegetables significantly reduced Daniell wrinkle scores after controlling for variables such as age and BMI. Also, it seems that skin elasticity significantly improved with increased intake of total fat, saturated fat, and monounsaturated fatty acids. In a prospective study of Australian adults aged <55 years, it was confirmed that groups (especially those aged 45 years and older) who consumed more antioxidant foods (e.g., fruits, vegetables, unrefined grains, teas, and oily fish) had a significant reduction in photodamage ($p=0.037$) [26]. Furthermore, a prospective study published in 2009 found that people who consumed more oily fish had a lower prevalence of actinic keratosis (AK) and that the probability of developing AK could even decrease to 27% with increased wine consumption [27]. The abundance of bioactive nutrients in the Mediterranean diet has been shown to have some photoprotective effects.

Therefore, the Mediterranean diet is undoubtedly an ideal diet that not only helps to maintain cardiovascular health, but also effectively slows down skin aging and various injuries.

3.2. Western Diet

The Western diet in the US is high in red and processed meats, full-fat dairy, refined grains, sodium, and sugars, with low fiber and whole grains. NHANES data (2001-2018) shows ultra-processed foods make up 40-60% of the diet, with over 70% of the food supply being ultra-processed. This pattern is linked to major health issues like cardiovascular disease, cancer, diabetes, and stroke, driven by high intake of saturated fats and sodium. And since the benefits of the nutrients mentioned above are not just for the skin, but also for cardiovascular benefits, it is clear that the western diet may not be one of the better dietary patterns for skin care.

3.3. Vegetarian and Vegan Diet

Vegetarian and vegan diets are dietary patterns that are based on animal and environmental considerations and do not include meat, poultry, fish, or any dairy products or eggs, or are egg-lacto vegetarian, which is a vegan diet with the addition of dairy products or eggs. It has also been mentioned in the 2023 AHA Statement that for vegetarian diet and vegan diet, although it is basically in line with the nutrient intake patterns recommended by the Heart Association, adults following such dietary patterns are at risk of macronutrient or micronutrient deficiencies, especially vitamin b12 deficiency, which may cause some bad effects on the skin [28].

However, for a vegetarian dietary pattern, less healthy carbohydrates are usually consumed to ensure the intake of all types of nutrients, which results in a diet that may contain more highly processed foods or added sugars ETC. so it is more likely to raise triglycerides and lower LDL, which can increase the incidence of AD or acne.

3.4. Low-Carb Diet

The LCD diet is a dietary pattern of less than 45% carbohydrate intake, primarily vegetables and fruits, whole grains, low-fat dairy products, and lean proteins, but lacking more nuts and healthy oils.

While low-carb diets may be beneficial for weight management and metabolic health, their effects on skin health are unclear. Some studies suggest that this diet may lead to decreased skin moisture levels and dry skin, and that low antioxidant intake may make the skin more susceptible to oxidative stress and environmental factors.

Choosing a healthy low-carb diet will be important, and as with the vegan model described above, care should be taken to avoid ultra-processed foods, refined foods, etc. Although for those who adhere to this dietary pattern, both men and women have a higher likelihood of being white-skinned, high-income, and having better health [29]. It is possible negative health effects still cannot be ignored. Overall dietary balance and nutrition should be ensured so as to provide health promotion and skin care.

4. Applications

While taking dietary supplements or foods containing these nutrients is indeed one of the most direct methods of intake for the practical application of these nutrients, supplementation of nutrients through topical skincare products for the benefit of the skin is also the subject of current research. Grape seed, as a very common dietary supplement with antioxidant and anti-inflammatory properties, has demonstrated high antioxidant and antimicrobial activity for both skin care and cosmetic applications, with seed mixtures of five grape varieties commonly used in port wines (GSE-Sv) and one wine grape variety commonly used in table wines (GSE-Ov), and grape seed extracts also inhibit melanin production through modulation of reduced tyrosinase activity. tyrosinase activity to inhibit melanin production, thus obtaining skin whitening effects [30]. In the case of coenzyme Q10, a fat-soluble molecule that has been on fire after the new coronavirus pneumonia outbreak, the cardiovascular system can benefit from coenzyme Q10 as well as the skin's defense against oxidative stress, and the topical application of coenzyme Q10-containing skincare products has been found to result in proliferation of collagen, improvement of skin elasticity, and a reduction in the occurrence of wrinkles and signs of aging [31]. Similarly, for cosmetic products made from caviar oil, a caviar extract rich in essential fatty acids and amino acids, the epidermal and dermal layers of the skin tissues showed a better degree of absorption, and it could be found that the rate of change in wrinkles after four weeks of use was 51.56%, demonstrating a better skin care effect [32].

5. Conclusion

In general, plant extracts, alkaloids, vitamins, carotenoids and antioxidants, esters and fatty acids, collagen, prebiotics and probiotics are nutrients that can benefit the skin to varying degrees, whether they are consumed in the diet or supplemented with topical skincare products. As for dietary patterns, there is no doubt that the Mediterranean pattern, which is now widely respected as a healthy dietary pattern, also has a healthy impact on the skin, and the Western dietary pattern, the vegetarian dietary pattern, and the low carb diet all embody different dimensions of impact on the prevalence of AD or other skin-related conditions, and are subject to further debate and improvement. However, dietary interventions for skin care are too diverse in terms of nutrient content to make this issue complex but valuable to study, as a nutritious diet is necessary for everyone to maintain good health and is the simplest self-regulating approach to wellness, so this may be actively explored in the future to maximize the health, and especially the skin health benefits.

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