Introduction

The 60 billion US Dollar beauty industry continues to flourish spurred by the consumers’ desire to look and feel forever-young. Several categories exists within the beauty industry but none more vibrant than the anti-aging segment which contain products to reduce or reverse the visible signs of aging such as wrinkles, age spots, and freckles. While aging is natural and cannot be avoided, there are factors such as solar radiation, physical and mechanical damage that accelerate the propensity of visible aging. For example, humans in general face increasing exposure to chemical pollution, ultraviolet radiation and ozone levels which damage the skin’s dermal layer causing wrinkles and potentially more deadly; the risk of malignant skin cancer. These negative effects are compounded with increasingly poor diets and life-style habits which are not conducive to maintaining the skin’s natural repair process and antioxidant network. Clearly, there is an opportunity for natural ingredients to help improve long term skin health management by topical application combined with nutritional supplementation.

In human trials, Astaxanthin has been shown to reduce visible signs of UV-aging either by topical or dietary supplementation within 4 to 6 weeks of use. This data is supported with a number of in-vitro and animal studies. Research suggests potential skin benefits with the use of astaxanthin to maintain a youthful appearance, reverse premature signs of aging and a prophylactic approach against UV induced skin cancer.

In the past, Beta-carotene (provitamin A) and Vitamin E have been extensively studied, but now other carotenoids such as astaxanthin derived from the microalgae Haematococcus pluvialis have shown to have potent quenching and anti-lipid peroxidation properties; a weakness of Beta-carotene and Vitamin E (Miki, 1991).

Naturally, further investigations are necessary to elucidate the mechanism of action as well as demonstrating the same benefits at significantly larger clinical trials. To date, the astaxanthin potential is promising.

“Skin is exposed to chemical, physical, and mechanical damage causes premature aging of the epidermis.”

“Astaxanthin is produced by Haematococcus in direct response to protect cells in vivo against UV induced oxidative stress.”

**Table 1. Astaxanthin maintains skin health by several methods**

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Mechanism</th>
<th>Topical Route</th>
<th>Dietary Route</th>
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<tbody>
<tr>
<td>Increase skin’s ability to resist environmental stripping of skin nutrients.</td>
<td>Restores skin’s natural antioxidant balance (SOD, CAT, GSH). Protects cell membrane against lipid peroxidation.</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Reduce puffiness and sun burn.</td>
<td>Suppresses the inflammatory pathway.</td>
<td></td>
<td>✓</td>
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<tr>
<td>Prevent &amp; reduce presence of UV induced wrinkles. Firmer and elastic skin. Increased moisture.</td>
<td>Protects the dermal layer against oxidative stress dysfunction. Allowing repair process to heal collagen network.</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Reduce the risk of skin cancer.</td>
<td>Protects against accumulated DNA damaged.</td>
<td></td>
<td>✓</td>
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**Protecting the Skin’s Natural Antioxidant Network and DNA**

Oxygen radicals formed by UV radiation attack the skin cells in a variety of ways. As demonstrated by O’Connor & O’Brien (1998), UVA light is capable of producing oxidative stress in living cells in-vitro. By monitoring catalase (CAT), superoxide dismutase (SOD) levels and thiobarbituric acid reactive substances (TBARS), Astaxanthin is capable of reducing oxidative stress (p<0.01, n=6) after UVA light irradiation at very low concentrations (5-10 nM). Compared to lutein or beta-carotene (1.0 µM), astaxanthin was approximately 100-200 times more effective than other carotenoids.

Similar reports by Lyons et al., (2002) demonstrated that UVA irradiated skin cells pretreated with astaxanthin (10 µM) suffered significantly less DNA damage. Furthermore, astaxanthin protected the skin’s endogenous antioxidants SOD and glutathione (GSH) from oxygen radical attack.

Topical restoration of the skin’s natural antioxidant balance is one method to maintaining skin health. UV radiation and air borne pollutants tend to strip away the nutrients which are needed to maintain the skin’s hydrolipidic barrier. As a result, the skin will tend to become dry and unhealthy looking.

**Topical Wrinkle Reduction**

Arakane (2002) demonstrated using hairless mice, astaxanthin’s ability to suppress the formation of UVB photo-induced wrinkles. The UVB dose was 65-95 mJ/cm2, five times per week for 18 weeks on the back skin of mice. After each UVB treatment, topical application astaxanthin (350 µM) were used on the exposed areas. From 5 weeks, the appearance of new wrinkles were significantly reduced up until the end of the study period (P<0.01 at 18 weeks). Concurrently, stained skin sections revealed that astaxanthin preserved the integrity of the dermal layer by protecting the collagen network.
In a preliminary human study, Seki et al. (2001) demonstrated the same anti-wrinkle observations on female human subjects (n=3) using a topical cream containing astaxanthin. A dermatological assessment revealed significant reduction of wrinkles and puffiness on the lower eye and cheeks at 2 weeks.

In a separate test using female subjects (n=11), instrument analysis recorded significant moisture improvement (P<0.05) at 3 weeks (Figure 1). The second study by Yamashita (2006), female subjects with a variety of skin types (n=49, mean age 47) were given either 4 mg (2 x 2 mg) astaxanthin or placebo in this single-blind, randomized, controlled study. After six weeks of consuming 4mg astaxanthin per day, the results of the questionnaire showed that the treated group all felt that their skin condition had improved (Figure 4).

Figure 3. Magnified Skin Section at start, 2 and 4 weeks (Yamashita, 2002)

Instrument analysis showed the treated group had indeed achieved positive results in hydration (P<0.05) and elasticity (P<0.05). Furthermore, a dermatologist inspection showed wrinkle reduction (P<0.05) and improved elasticity (P<0.05) in the treated group especially between weeks 3 and 6 (Figure 5). This is significant because skin regeneration usually takes between 4-5 weeks. The greatest improvement seen at week 6 supports the theory that astaxanthin protects and allows skin to regenerate.

Figure 4. Subject response after 6 weeks astaxanthin supplementation (Yamashita, 2006)

Astaxanthin reduced wrinkles and increase elasticity.

Astaxanthin and Skin Cancer

The risk of skin cancer increases with skin which is frequently damaged by sun. Although skin cancer is almost 99% curable if detected early, 1 out of 90 people in the US or 1 out of 150

Skin Improvements seen in all categories after astaxanthin supplementation (Yamashita, 2006).
people in the UK will develop melanomas. The high risk category is when the skin experiences sudden, short bursts of strong sunlight. Sun screens can block the UV, but dietary carotenoids like astaxanthin can help protect skin too.

Black (1998) demonstrated using hairless mice that astaxanthin significantly delayed the UV formation of skin lesions and tumors (p<0.05). One reason could be that astaxanthin is preferentially accumulated compared to beta-carotene and lycopene. Epidermal analysis determined the quantity of astaxanthin was 133 times that of lycopene and 28 times that of Beta-carotene.

Further support comes from Savoure et al., (1995) who showed that in hairless mice (SKH1) deficient in vitamin A, fed 10 mg/kg/feed astaxanthin alone or in combination with retinol showed enhanced skin protection after UVA and UVB irradiation. Astaxanthin significantly inhibited accumulation of putrescine (p<0.05) more than retinol as well as lowering spermidine and spermine.

Mechanism of Action

Skin is composed of three layers: the epidermis, the dermis, and the subcutaneous fat. The dermis contains collagen, elastin, and other fibers that support the skin’s structure. It is these elements that give skin its smooth and youthful appearance – and that are damaged by UV radiation (UVR).

Anti-wrinkle

The UVR that affects the skin is composed of two different types of waves, UVA and UVB. UVB rays are shorter than UVA rays, and are the main cause behind sunburn and melanin production. But it is the UVA rays, with their longer wavelength, that are responsible for much of the damage associate with photoaging. UVA rays penetrate deep into the dermis, where they damage the collagen fibers leading to wrinkle formation (Figure 6).

UV exposure produces in situ oxygen radical species which destroy the collagen network and disrupt the repair mechanisms. For example, the skin responds by the production of enzymes called metalloproteinases (MMP) as a result. These enzymes, which rebuild damaged collagen, often malfunction and degrade the collagen, resulting in incorrectly rebuilt skin. Astaxanthin attenuates the effects of reactive oxygen radicals on MMP and allows the skin to regenerate properly (Figure 7).

Astaxanthin defends against Reactive Oxygen Species (ROS).

Oxygen present in our cells can form harmful radicals known as ROS or active oxygen when sufficient energy like UV is applied. These are singlet oxygen, superoxide and hydroxyl radical (leading to peroxyl radicals) and these attempt to steal electrons from other neighbouring molecules to stabilize itself such as DNA, phospholipids, enzymes and protein. Fortunately, astaxanthin is able to quench singlet oxygen and supress lipid peroxidation much better than other well known antioxidants and thus control the presence of ROS more effectively.

Anti-inflammatory Action

Sun burn or inflammation that normally follows sun exposure can be modulated by a powerful antioxidant. Yamashita (1995) showed in healthy male subjects (n=7) that topical natural astaxanthin significantly reduced burn level (erythema) by 60% at 98 hours after UVB exposure. We now know that astaxanthin works by suppressing the proinflammatory mediators and cytokines via the IκB kinase dependant NF-κB activation pathway (Lee et al., 2003).

Figure 6. Illustration showing effect of UVA, UVB & Ozone on skin

Safety for Topical & Nutritional Use

Astaxanthin is determined safe for topical use. A total of forty-five subjects (males and female) were exposed to the Standard Japanese Patch test and results reported 24 and 48 hours after application. Dermatitis was only induced by the adhesive plaster and not astaxanthin itself (Seki et al. 2002). Furthermore, Koura (2005) reported no adverse topical reactions in animal sensitization models.

Figure 7. Illustration showing singlet oxygen removal with astaxanthin helps the skin renewal process.
Outlook

Naturally, the best method to stop photo-aging is through removal of the solar effects on skin with sunscreen to areas vulnerable to photo-aging. However, recent surveys reveal that people in general are not doing enough to protect their skin. The use of powerful carotenoids like astaxanthin in topical and nutritional skin products can help deliver the benefits against the risk of accelerated photo-aging and skin cancer.

References

1. www.skincancer.org/

2. www.skincancerfacts.org.uk/facts.asp


