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ASTAXANTHIN IN EYE HEALTH

Introduction:

The eye is subjected to continuous light exposure because the primary purpose of the eye is light perception. Therefore, some untreatable diseases and injuries to the eye result from the continuous exposure of the eye to light coupled with the highly oxygenated environment in the eye. Two of the leading causes of visual impairment and blindness are age-related macular degeneration (ARMD) and age-related cataracts [1,2].

Macular degeneration is a progressive disorder affecting the central part of the retina, called the macula. Macular degeneration results in a gradual loss of photoreceptor cells and is the leading cause of irreversible blindness. Prevention is crucial, since there are few successful treatments for this disease. Both cataracts & ARMD appear to be related to light-induced oxidative processes within the eye [1,3,4 & 5]. While cataracts affect the lens, the macula is damaged in ARMD. Both the lens and the retina are exposed continually to light (particularly blue light) and oxygen, which can work together to produce oxygen free radicals. In cataract formation, free radicals appear to impair the lens crystalline proteins, causing them to clump, and also damage proteolytic enzymes that would normally remove the damaged proteins [6]. In the retina, with its high levels of oxygen and polyunsaturated fatty acids, peroxidation of membranes likely leads to the death of photoreceptor cells[1]. It is therefore not surprising that factors known to be related to oxidation (cigarette smoking, cardiovascular disease, exposure to sunlight, low ocular melanin content) have been shown in epidemiological studies to be related to an elevated risk for ARMD [3,7].

Carotenoids:

One of the challenges associated with eye nutrition is the body's limited ability to deliver nutrients to the proper areas in the eye. It has been shown that a higher dietary intake of carotenoids is associated with a 43% lower risk of AMD. In humans and other animals, carotenoids are essential for proper health of the eye, a number of studies have demonstrated that dietary carotenoids help to protect the retina against oxidative damage [3]. Carotenoids seem to play an important role in nature in protecting tissues against UV-light mediated photo-oxidation and are often found in tissues directly exposed to sunlight. Oxidative damage to the eye has been widely documented [5].

Carotenoids have multiple unsaturated bonds. This allows them to absorb high-energy light waves in the blue and near ultraviolet regions of the spectrum. Carotenoids within the macula are perfectly suited to absorb this high-energy blue light and act as an antioxidant to thereby quench these damaging oxygen species.

Lutein & Zeaxanthin:

Among the carotenoids, scientific studies have evidenced the importance of only two carotenoids in eye health - Lutein & Zeaxanthin, as these two nutrients are known to protect against cataracts and AMD[8]. Lutein & Zeaxanthin are oxygenated carotenoid called the xanthophyll. Because it is oxygenated, a xanthophyll has greater antioxidant capacity than many other carotenoids. From the many carotenoids in the diet, the human retina selectively accumulates only two: zeaxanthin and lutein[9&10]. Their concentration is so high in the macula[11], and in the lens of the eye[12] that the carotenoids are visible as a dark yellow spot called the macular pigment. The reason that the macula or center of the retina is called Macula lutea is because of lutein.

Lutein and zeaxanthin, which are primarily obtained from dark and leafy vegetables, were most strongly associated with the reduced risk of AMD [13]. The two functions of Lutein & Zeaxanthin are: First, they filter out damaging ultraviolet blue light[14]. Second, they protect against oxidative damage by quenching free radicals[15] in the eye. A recent study with human eyes from postmortem donors revealed a specific protein that selectively binds lutein and zeaxanthin[16], explaining why they are predominant in the macular pigment. Recent studies indicate that lutein and zeaxanthin are found in significant quantities within the outer segments of Retina[17&18]. Zeaxanthin has been shown to be nearly twice as strong as lutein in terms of singlet oxygen quenching, a measure of antioxidant strength.

The macula acquires its characteristic "yellow spot" appearance from the accumulation of carotenoid pigments. Lutein is found in higher concentrations away from the fovea, which is in the center of the macula, while zeaxanthin concentrates closer to the fovea.[19] Lutein is converted to zeaxanthin in the retina. Some dietary lutein appears to be converted to a non-dietary form of zeaxanthin (meso-zeaxanthin). Infants have more lutein and less meso-zeaxanthin, leading to the speculation that they may not convert lutein as efficiently. Zeaxanthin appears to be preferentially taken up by cones, while lutein has an affinity for the rods.[20]

Please refer our article "Lutein & Zeaxanthin in Eye Health" for more information on Lutien and zeaxanthin's role in eye health.

Astaxanthin in Eye Health:

Another carotenoids that has been associated with eye health, but has received considerably far less attention than lutein and zeaxanthin is astaxanthin. Astaxanthin is a natural carotenoid pigment red in colour. This xanthophyll is a fat-soluble nutrient, which is a potential antioxidant more powerful than other antioxidants like betacarotene, Vit. E & Vit. C. Astaxanthin has demonstrated powerful antioxidant activity and other beneficial properties for human health. Studies suggest that astaxanthin function in synergy with vitamin E and other antioxidants.

A growing body of scientific literature reveals significant evidence that astaxanthin surpasses the antioxidant benefits of beta-carotene, zeaxanthin, canthaxanthin, vitamin C and vitamin E. Animal cell culture studies have also indicated that astaxanthin can ameliorate age-related macular degeneration.

Astaxanthin's ability to quench singlet oxygen and scavenge free radicals has been demonstrated by a number of in vitro and in vivo studies. Unlike Lutein and zeaxanthin, Astaxanthin has not been isolated in the human eye, yet it is found in the eye or eye parts of a number of animals [21]. Scientific studies suggest that Astaxanthin is also an important nutrient in the area of eye-health because,

1. The composition of the astaxanthin is very close to that of lutein and zeaxanthin, yet it has demonstrated, in in-vitro studies, a stronger antioxidant activity and UV-light protection effect than these two other carotenoids [22]. It could therefore be inferred that deposition of astaxanthin in the eye might provide superior protection against UV light and oxidation of retinal tissues.

2. Astaxanthin's unique molecular structure gives it a superior antioxidant capacity. Due to its particular molecular structure, astaxanthin serves as an extremely powerful antioxidant. It has a very powerful scavenging ability for free radicals [23].

3. Astaxanthin is an oxygenated carotenoid called a xanthophyll. Because it is oxygenated, a xanthophyll has greater antioxidant capacity than many other carotenoids. Within the xanthophylls, the Astaxanthin molecule contains the longest conjugated, double-bond polyene chain along with both hydroxy and carbonyl groups at each end. This configuration supports the greatest antioxidant capacity, its peroxyl radical chain-breaking abilities, its incorporation of free radicals into its polyene chain, thereby more effectively trapping them, and its enhancement of Vitamin C as an antioxidant. While other carotenoids and antioxidants may perform one or two of these functions, Astaxanthin does them all and, in most cases, does them better. In addition to entrapping free radicals, Astaxanthin also de-charges singlet and triplet oxygen and inhibits reactive oxygen, giving it anti-inflammatory properties.

4. Astaxanthin has almost 4 times the antioxidant capacity of lutein, is superior protection against UVA and UVB light-induced oxidative stress, is more stable in scavenging and quenching than betacarotene, canthaxanthin and zeaxanthin. The antioxidant properties of astaxanthin are believed to play a key role in many of the health conditions including the eye health. It has been demonstrated that astaxanthin is significantly more effective in neutralizing free radicals than beta-carotene and protects against peroxidation of unsaturated fatty acid methyl esters better than canthaxanthin, beta-carotene or zeaxanthin [24]. In fact, the antioxidant activities of astaxanthin have been shown to be approximately 10 times stronger than other carotenoids such as zeaxanthin, lutein, canthaxanthin and beta-carotene [25].

5. Astaxanthin crosses the blood-brain barrier which makes it available to the eye, brain and central nervous system to
   a. Alleviate oxidative stress that contributes to ocular and neurodegenerative diseases such as glaucoma and Alzheimer's.
   b. It protects the retina against photo-oxidation and loss of photoreceptor cells.
   c. Since it crosses the blood-brain barrier, like lutein will deposit in the retina of mammals if included in the diet [26].

6. Astaxanthin does not form crystals in the retina, and has been proposed in a patent as a preventive or treatment for certain retinal disorders such as age-related macular degeneration. In rat studies discussed in the patent astaxanthin was shown to reduce photoreceptor cell damage caused by light exposure [26].

7. Last but not least, Astaxanthin has the ability to protect the neurons of the retina as well as those of the brain and spinal cord, from damage caused by free radicals (US Patent 5,527,533).

Research: Astaxanthin's protective effect in the eye:

1. In the study by Tso et al.[26], the retinal photoreceptors of rats fed astaxanthin were less damaged by a UV-light injury and recovered faster than animals fed no astaxanthin, confirming the potential of astaxanthin for eye health. No human clinical study on effect of astaxanthin in specific eye diseases like macular degeneration or cataract has been published yet.
2. In the results of a similar follow-up study with oral administration of astaxanthin to measure the effects of photic injury on rhodopsin levels in the eye, the authors indicated that the astaxanthin not only protects the receptor cells from photic injury but also ameliorates the effects of the damage (US Patent 5,527,533).
3. The study by Tso et al., [26] that demonstrated that astaxanthin supplementation helped protect the retinal photo-receptors in the eyes of rats exposed to acute UV-light injury plus the stronger in vitro protective effect of astaxanthin against UV-induced photooxidation [22], when compared to β -carotene and lutein, suggest that it has an excellent potential as an oral sun-protectant.

4. An animal study with rats to find the ability of astaxanthin to ameliorate injury to neurons after retinal ischaemic insult and subsequent reperfusion demonstrated that astaxanthin provided statistically-significant protection to the ganglion cells and other neuronal elements of the inner retina from ischaemic insult.

The tests have shown that astaxanthin can protect or rescue neurons and other cell types, and that astaxanthin is an effective therapeutic agent to ameliorate photoreceptor degeneration and ischemic damage to neurons of the retina. It has also been shown that the administration of a therapeutically-effective amount of astaxanthin to an individual prevents, retards and / or ameliorates damage to the central nervous system, and especially to the eye, resulting from disease or injury.

Conclusion:

It should be noted that

1. Carotenoids either dietary or in the form of supplements have been associated with stronger health benefits including the eye health.
2. Most of the studies on the carotenoids have focused on administering either of the carotenoid and not a combination of carotenoids to find the efficacy of each carotenoid.
3. It is important to note that a combination of carotenoids to be administered, because this will have a synergistic effect than administering a single carotenoid.
4. Hence, in the area of eye health, a person should take a combination of lutein, zeaxanthin and also astaxanthin, which will have a very protective effect and there by preventing further ill effects.

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