Annals of Agri-Bio Research **29** (2): 52-70, 2024 **Impact Score : 0.28 (Scopus)**

Role of Nutrients in Eye Health

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(Received: June 12, 2024; Accepted: November 20, 2024)

ABSTRACT

Nutrition is an important lifestyle factor that can have a long-term impact on eye health. Globally, approximately 250 million people suffer from varying degrees of vision loss. Blindness and severe vision impairment are serious public health concerns. Eye disorders due to nutritional deficiency continue to be one of the major contributors to blindness in developing countries, whereas, in developed countries, age-related macular degeneration, night blindness, cataract, nutritional amblyopia, nutritional optic neuropathy, and retinitis pigmentosa are the leading causes. This paper discusses the function of nutrients including vitamins, multivitamin supplements, carotenoids, xanthophyll, minerals, curcumin, antioxidants, lactoferrin, polyphenols, omega-3 fatty acids, and curcumin in the prevention of various eye conditions. These nutrients have been demonstrated to be beneficial to eye health. To conclude, maintaining healthy nutrition has an impact on eye health influencing the quality of life.

Contribution: There are numerous foods and supplements to enhance eye health and prevent vision deterioration. With strict adherence, one can achieve both improved general and eye health.

Key words: Nutrition, nutrient intake, prevention, eye health, blindness, visual impairment, public health, eye diseases

INTRODUCTION

The effects of every dietary ingredient on humans are covered by the scientific study of human nutrition. The biochemical and physiological process by which an organism uses food to sustain its life is referred to as nutrition. Nutrients are substances that an organism requires to survive, grow, and reproduce (Andrews., 2017). Chemicals included in food known as essential nutrients are those that are required for survival, growth, and tissue repair but cannot be produced by the body in sufficient amounts or at all (Mann & Truswell., 2017). The most crucial nutrient for survival is water. Carbohydrates, dietary fibre, fats, proteins, minerals, vitamins, and water are the seven major classes of relevant nutrients for humans (Shruthi, 2022). Nutrients are classified as macronutrients (carbohydrates, dietary fibre, fats, proteins, and water required in gram amounts) or micronutrients (vitamins and minerals needed in milligram or microgram quantities). Human nutrition is concerned with the provision of essential nutrients from the food that are required to sustain human life and health.

Globally, approximately 250 million people suffer from varying degrees of vision loss (Flaxman et al., 2017). Blindness has affected more than 39 million people worldwide, and this number is steadily increasing as the world's population grows. Diseases affecting several parts of the eye can cause vision loss, but the majority of these problems damage the retina and ultimately result in irreversible blindness (Piano et al., 2021). Global blindness is a pandemic, according to the WHO (World Health Organization), with 285 million people worldwide visually handicapped. In developing nations, cataracts and age-related macular degeneration (AMD) are the leading cause of vision impairment and blindness. While Dry Eye Syndrome (DES) poses a lower risk of vision loss, it is the most prevalent ophthalmologic complaint, with 68% of people aged 60years and up experiencing DES symptoms and discomfort (McCusker et al., 2016). In 2015, 36 million individuals were blind (visual acuity less than 3/60), 217 million had moderate or severe vision impairment (worse than 6/18 but 3/60 or better), and 188 million had mild vision impairment (worse than 6/12 but 6/18 or better). Vision loss and age-related eye illnesses harm economic and educational opportunities, as well as a lower quality of life and an increased risk of death (Bourne et al., 2017). Vision impairment can be caused by a variety of circumstances, but one that is more easily remedied than others is inadequate nutrition (Solebo et al., 2021).

Blindness is defined as the state of being sightless. A completely blind individual is unable to see at all. The word blindness, however, is commonly used as a relative term to signify visual impairment or low vision. In a strict sense, the word 'blindness' denotes the inability of a person to distinguish darkness from bright light in either eye. Vision impairment refers to when you lose part or all of your ability to see (or vision). The impairment must persist even with the use of eyeglasses, contact lenses, medication, or surgery. Vision impairment can range from mild to severe

(Dahl., 2022). Visual impairment and blindness continue to be major public health issues around the world (Pascolini & Mariotti., 2012) (refer Table 1).

This review tries to address important nutrients and its % of intake for overall good health of the ocular system (refer Table 2).

Table 1. Category of visual impairments.

Mild or no visual impairment	Vision better than or equal to 6/18
Moderate Visual impairment	Vision worse than 6/18, but equal to or better than 6/60
Severe Visual impairment	Vision worse than 6/60, but equal to or better than 6/120
Blindness	Vision worse than 6/120

Table 2. Nutrients required for prevention /treatment of eye diseases leading to blindness and visual impairment.

Eye disease/disorder	Nutrient	Main source	Recommended daily allowance in mg			
			Birth-10yr	11yr-20yr	>20yr Male	>20yr Female
Age related macular degeneration	Iron (John, 2018)	Oyster, dark chocolate, tofu, lentils	13.7-15.1 mg	8.7 mg	14.8mg	14.8 mg 27mg (pregnant)
	Zinc (National Institutes of Health [NIH] Office of Dietary Supplements, 2021)	Turkey, crab, oysters, beef	3-11mg	11mg	11mg	8mg
	Selenium (Cejkova et al., 2008)	Meat, fish, seafood, cereal	0.03-0.04 mg	0.055mg	0.055mg	0.06mg (pregnant) 0.07mg (breast feeding)
	Vitamin B6 (National Institutes of Health [NIH] Office of Dietary Supplements, 2022)	Banana, avocado, egg, salmon	0.1-1mg	1.3mg	1.3mg	1.9mg (pregnant) 2mg (breast feeding)
	Vitamin B12 (Selinger et al., 2019); (National Institutes of Health [NIH] Office of Dietary Supplements, 2022)	Intra-muscular injection/ eye drops supplements; Meat, milk, egg, fish,	0.4-1.8mg	0.0024mg	0.0024mg	2.6mg (pregnant) 2.8 (breast feeding)
	Vitamin C (Institute of Medicine, 2000)	Sweet pepper, kale, citrus fruit, strawberry	15-45 mg	50-80 mg	90 mg	70 mg (85 mg pregnant) (120 mg breast-feeding)
	Vitamin D (Institute of Medicine, 2010)	Fish, oil, egg, salmon	0.01-0.07 mg	0.07 mg	0.07 mg	0.07 mg
	Vitamin E (U.S. Food and Drug Administration [FDA], 2016)	Broccoli, spinach, almonds, peanut butter	4 mg to 11 mg	11 mg	15 mg	15 mg (pregnant) 19 mg (breast feeding)
	β-carotene (Gorusupudi et al., 2017)	Leafy green vegetables and fruits, carrot, sweet potato, spinach	15-180 mg	15-180 mg	15-180 mg	15-180 mg

	Xanthophyll (Peter, 2021)	Spinach, broccoli, eggs, kale	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin
	Antioxidant (Pellegrini et al., 2020)	Fruits and vegetables	500 mg of vitamin C	500 mg of vitamin C	500 mg of vitamin C	500 mg of vitamin C
	Vitamin B6 + B12 + B9 (Christen et al., 2009)	Animal liver, beef, sardines, calms	0.4 mg + 0.9-0.0018 mg + 0.065-0.3 mg	1.3-1.2 mg + 0.0024 mg + 0.4 mg	1.3-1.7 mg + 0.0024 mg + 0.4 mg	1.3-1.5 mg + 0.0024 + 0.5 mg (pregnant) 0.6 mg (breast feeding)
Night blindness (Nyctalopia)	Vitamin A (World Health Organization [WHO], 1997); 7507mg RE/wk	Beef/chicken liver, eggs, butter, milk, carrots	0.6-1.7 mg	0.9-1.2 mg	0.9-1.3 mg	0.9-1.3 mg
	Zinc (National Institutes of Health [NIH] Office of Dietary Supplements, 2021)	Turkey, crab, oysters, beef	3-11mg	11mg	11mg	8mg 1 mg (pregnant) 12 mg (Breast feeding)
Cataract	Vitamin B2 (National Institutes of Health [NIH], Office of Dietary Supplements, 2022)	Beef liver, fortified cereal & oats, yogurt, milk	0.3-1 mg	1 mg	1.3 mg	1.1 mg 1.4 mg (pregnant) 1.6 mg (breast feeding)
	Vitamin C (Institute of Medicine, 2000)	Sweet pepper, kale, strawberry, broccoli	25 mg	45 mg	90 mg	70 mg 85 mg (pregnant) 120 mg (breast feeding)
	Vitamin E (U.S. Food and Drug Administration [FDA], 2016)	Broccoli, spinach, almonds, peanut butter	4-11 mg	11 mg	15 mg	11 mg (pregnant) 19 mg (breast feeding)
	Carotenoid (Gorusupudi et al., 2017)	Leafy green vegetables & fruits, spinach, carrot	0.6-1.7 mg	0.9-1.2 mg	0.9-1.3 mg	0.9-1.3 mg
	Lutein & zeaxanthin (Peter, 2021)	Spinach, broccoli, egg, kale	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin	10 mg lutein, 2 mg zeaxanthin
Ocular surface disease	Curcumin (WebMD Editorial Contributors, 2020)	Fruits & vegetables, dairy products, turmeric, soup	0.6 mg/kg of body weight	0.6 mg/kg of body weight	0-3 mg/kg of body weight	0-3 mg/kg of body weight
	Vitamin C. (Institute of Medicine, 2000)	Sweet pepper, kale, strawberry, broccoli	25 mg	45 mg	90 mg	70 mg 85 mg (pregnant) 120mg (breastfeeding)

	β-carotene (Gorusupudi et al., 2017)	Leafy green vegetables and fruits, carrot, sweet potato, spinach	15 mg	15 mg	15-180 mg	15-180 mg
	Antioxidant (Pellegrini et al., 2020)	Fruits & vegetables	500 mg vitamin C	500 mg vitamin C	500 mg vitamin C	500 mg vitamin C
Dry eye syndrome	Omega-3 FA (Pellegrini et al., 2020); 35mg DHA	Walnut, trehalose, flaxseed oil & dark, cold-water fish like salmon	220 mg EPA 1,000 to 2,500 mg DHA	220 mg EPA 1,000 to 2,500 mg DHA	220 mg EPA 1,000 to 2,500 mg DHA (but for cardiovascular benefits, the AHA* recommends ~1,000 mg	220 mg EPA 1,000 to 2,500 mg DHA (but for cardiovascular benefits, the AHA* recommends ~1,000 mg
	Vitamin A· (National Institutes of Health [NIH], Office of Dietary Supplements, 2022) (Palmitate)	Animal sources - beef/chicken liver, eggs	0.6-1.7 mg	0.9-1.2 mg	0.9-1.3 mg	0.9-1.3 mg
	Vitamin B1 (National Institutes of Health [NIH], Office of Dietary Supplements, 2021)	Meat, fish, whole grain, fortified cereal	0.5-0.8 mg	0.9 mg	1.2 mg	1.1 mg 1.4 mg (pregnant and breast feeding)
	Vitamin B2 (National Institutes of Health [NIH], Office of Dietary Supplements, 2022)	Beef liver, fortified cereal & oats, yogurt, milk	0.3-1 mg	1 mg	1.3 mg	1.1 mg 1.4 mg (pregnant) 1.6 mg (breastfeeding)
	Vitamin B12 (National Institutes of Health [NIH] Office of Dietary Supplements, 2022)	Eye drops / intramuscular injection supplements; Meat, milk, egg, fish,	0.0004-0.0018 mg	0.0018 mg	0.0024 mg	0.0024 mg 0.0026 (pregnant) 0.0028 (breastfeeding)
	Vitamin C (Institute of Medicine, 2000)	Fruits & vegetables – citrus, strawberry, cherry, tomato, broccoli	25 mg	45 mg	90 mg	70 mg 85 mg (pregnant) 120 (breastfeeding)
	Vitamin D (Pellegrini et al., 2020); (Yang et al., 2018)	Fish, oil, egg, salmon, milk	0.01 mg	0.015 mg	0.015-0.02 mg	0.015-0.02 mg

	Vitamin E (Hyon & Han, 2022); (U.S. Food and Drug Administration [FDA], 2016)	Almonds, sunflower seeds & hazelnuts; 3% diquafosol + vitamin E eye drops	4-11 mg	15 mg	15 mg	15 mg (pregnant) 19 mg (breastfeeding)
	Carotenoid (Gorusupudi et al., 2017)	Spinach, greens, carrot, sweet potato	0.6-1.7 mg	0.9-1.2 mg	0.9-1.3 mg	0.9-1.3 mg
	Antioxidant (Pellegrini et al., 2020)	Fruits and vegetables	500mg of vitamin C	500mg of vitamin C	500mg of vitamin C	500mg of vitamin C
	Selenium (Cejkova et al., 2008)	Meat, fish, seafood, cereal	0.03-0.04 mg	0.055 mg	0.055 mg	0.055 mg 0.06 (pregnant) 0.07 (breastfeeding)
	Lactoferrin (Melinda et al., 2018)	Cow &human milk, yogurt	1.8-3.6mg	1.8-3.6mg	1.8-3.6mg	1.8-3.6mg
	Flavonoid (Panche et al., 2016)	Tea, cocoa, red wine, citrus fruits	250-400 mg	250-400 mg	250-400 mg	250-400 mg
	Anthocyanin (Hitoe et al., 2014); (Wallace & Giusti, 2015)	Bilberry, maqui berry - 60d; wine, grapes, red/ purple vegetables, 100% non-citrus juice, yogurt	10.5 ± 0.8 mg	10.5 ± 0.8 mg	10.5 ± 0.8 mg	12.6 ± 1.5 mg
	Polyphenols (Hayakawa et al., 2020); (Perry, 2015) (EGCG &50 μM resveratrol – 24 hr)	Green tea, mulberry, peanut, grape	500–1500 mg	500–1500 mg	500–1500 mg	500–1500 mg
Nutritional amblyopia	Vitamin B1/ Thiamine (Nguyen et al., 2012); (National Institutes of Health [NIH], Office of Dietary Supplements, 2021)	Whole-grain, meat, fish, fortified cereal, pork	0.5-0.8 mg	0.9 mg	1.2 mg	1.1 mg 1.4 mg (pregnant and breast feeding)
	Vitamin B2/Riboflavin (National Institutes of Health [NIH], Office of Dietary Supplements, 2022)	Beef liver, fortified cereal & oats, yogurt, milk	0.3-1 mg	0.3-1 mg	1.3 mg	1.1 mg 1.4 mg (pregnant) 1.6 mg (breastfeeding)

	Vitamin B3/ Niacin (National Institutes of Health [NIH], Office of Dietary Supplements, 2021)	Meat, fish, poultry; milk, beef liver	2-12 mg	16 mg	16 mg	14 mg 18 mg (pregnant) 14 mg (breastfeeding)
	Vitamin B9/ Folate (National Institutes of Health [NIH], Office of Dietary Supplements, 2021)	Beans, beef liver, spinach, peas	0.065-0.3 mg	0.4 mg	0.4 mg	0.6 mg (pregnant) 0.5 mg (breastfeeding)
	Vitamin B12/ Cobalamin (National Institutes of Health [NIH] Office of Dietary Supplements, 2022)	Meat, poultry, whole milk, egg	0.0004-0.0018 mg	0.0018 mg	0.0024 mg	0.0024 0.0026 (pregnant) 0.0028 (breastfeeding)
Nutritional optic neuropathy	Vitamin B1 (National Institutes of Health [NIH], Office of Dietary Supplements, 2021)	Whole grain, meat, fish; fortified cereal	0.5-0.8 mg	0.9 mg	1.2 mg	1.1 mg 1.4 mg (pregnant and breastfeeding)
	Vitamin B9 (National Institutes of Health [NIH], Office of Dietary Supplements, 2021); Oral supplémentation – 5 mg	Legumes, yeast, fruit, leafy green vegetables	0.065-0.3 mg	0.4 mg	0.4 mg	0.6 mg (pregnant) 0.5 mg (breastfeeding)
	Vitamin B12 (National Institutes of Health [NIH] Office of Dietary Supplements, 2022);(Roda et al., 2020)	Meat, fish, fortified grain-based foods, eggs	0.0004-0.0018 mg	0.0018 mg	0.0024 mg	0.0024 0.0026 (pregnant) 0.0028 (breastfeeding)
	Copper (Roda et al., 2020); (National Institutes of Health [NIH], Office of Dietary	Beef liver, oyster, crab, turkey	0.2-0.7 mg	0.8 mg	0.9 mg	1.3 mg (pregnant and breastfeeding)

	Supplements, 2021					
Retinitis pigmentosa	Vitamin A (Roda et al., 2020); (National Institutes of Health [NIH], Office of Dietary Supplements, 2021); Vitamin A & E (capsules) (Hyon & Han, 2022); Vitamin A & lutein	Beef, chicken, eggs, milk	0.6-1.7 mg	0.9-1.2 mg	0.9-1.3 mg	0.9-1.3 mg
	Vitamin E (Hyon & Han, 2022)	Broccoli, spinach, peanut butter, almonds	4mg to 11 mg	11 mg	15 mg	15 mg (pregnant) 19 mg (breastfeeding)
	DHA (Hoffman et al., 2014)	Sea bass, salmon, herring, canola oil;	30mg	1,000-2,500 mg	1,000-2,500 mg	1,000-2,500 mg
	Lutein (Abdel-Aal et al., 2013)	Kale, spinach, Swiss chard, mustard	3 mg	3-6 mg	6-10 mg	6-10 mg
	β-carotene (Rotenstreich et al., 2013)	Butternut squash, sweet potato, kale, carrot,	15 mg	15 mg	15-180 mg	15-180 mg

Age-Related Macular Degeneration (AMD)

AMD is one of the leading causes of vision loss and blindness around the world. It's a medical disorder that causes blurred or no vision in the center of the visual field (National Institutes of Health [NIH] Office of Dietary Supplements, 2022a). AMD is most common in adults over the age of 50years and the major cause of permanent blindness in the elderly. It affects the macula, the core part of the retina where high-acuity daytime vision is achieved (Gorusupudi et al., 2017)

Minerals: Essential trace elements such as iron, zinc, copper, and selenium play important roles in retinal physiology (refer Table 2). In AMD retinas, there is a greater concentration of iron leading to oxidative stress (Blasiak et al., 2011). Zinc is the second most abundant metal in the human retina after iron, indicating that it has a significant physiologic role (Ugarte et al., 2013). Zinc deficiency causes poor dark adaption as well as lowered photopic and scotopic responses. In retinal pigment epithelial (RPE) cells and melanocytes, copper is required for the formation of melanin, a storage protein for iron, zinc, and copper (Gorusupudi et al., 2017).

Vitamins: Vitamin C, Vitamin E, Vitamin B6, Vitamin B12, and Vitamin B9, reduce the risk of AMD development (refer Table 2). Vitamin C can be present throughout the retina and may help to prevent AMD and act as a powerful anti-oxidant (Gorusupudi et al., 2017).

***Carotenoids*:** Lutein and zeaxanthin are significant dietary carotenoids in preventing and decreasing cataracts and AMD, according to research (Gorusupudi et al., 2017). A higher dietary intake of carotenoids, particularly lutein and zeaxanthin, is linked to a lower risk of AMD. These carotenoids are thought to lower the incidence of AMD by reducing retinal damage by absorbing high-energy blue light or by antioxidant action (Gorusupudi et al., 2017).

***Xanthophyll*:** Consumption of lutein and zeaxanthin in large amounts, notably from xanthophyll-rich foods, was linked to a considerable decrease in the occurrence of AMD (up to 40%) (Gorusupudi et al., 2017; Moeller et al., 2000).

Night Blindness (Nyctalopia)

Night blindness is a condition that affects people who have an underlying eye disease. A retinal illness or optical difficulties might cause night blindness.

Nyctalopia can be caused by a disease, injury, or condition that damages the rod cells (which are found in the retinal tissue) that are responsible for night vision. It's vital to note that night blindness does not refer to complete eyesight loss. Night blindness refers to a loss of vision at night or in dimly illuminated surroundings (Armenta & Huang et al*.,* 2022). Night blindness can be inherited or developed as a result of an injury or starvation (like vitamin A deficiency). (Wikipedia contributors, n.d.). The most common reasons are a loss of rod cells in the retina's capacity to respond to light over time and a retinol or vitamin A1 deficiency. ((Taren, 2012). The regeneration of rhodopsin, which influences vitamin A metabolism and neuron transmission, is influenced by a variety of nutrients (protein, minerals – zinc, and vitamins). The majority of metabolic alterations related to rhodopsin regeneration are linked to night blindness caused by vitamin A deficiency (VAD) (Taren, 2012).

Zinc: Zinc is essential for the creation of retinol-binding proteins, so a deficit could affect vitamin A delivery. Supplementing with vitamin A during pregnancy lowered the incidence of night blindness from 10.7% to 6.7% among controls. Zinc insufficiency can cause improper dark adaption (night blindness), which is a sign of VAD. Zinc deficiency, on the other hand, may not resolve night blindness or poor dark adaption on its own, but rather works as a potentiator for vitamin A in avoiding night blindness in zinc-deficient people (Christian et al*.,* 2001).

Cataract

A cataract is lens opacification leading to deteriorated eyesight. They are responsible for half of all occurrences of blindness and 33% of vision impairment globally (Pascolini & Mariotti, 2012). Consumption of green vegetables and fruits, as well as the avoidance of smoking, are all effective methods of prevention (National Institutes of Health [NIH], 2017). Clinical experiments, for a putative protective impact of the nutrients lutein and zeaxanthin, have shown that adequate intake of antioxidants (vitamin A, vitamin C, and vitamins E) can reduce the incidence of cataracts (Barker et al*.,* 2010).

Vitamin B2 (Riboflavin): It has anti-oxidant properties and can help prevent cataracts (Bourne et al*.,* 2017). Cataract has been connected to riboflavin deficiency (Semba, 2007).

Vitamin C: According to Jacques et al., people who consume more than 490 mg/d of vitamin C had a 75% lower risk of cataracts than those who consume less than 125 mg/d. According to Robertson et al (Christen et al., 2014) the prevalence of cataracts in people who took vitamin C supplements of >300 mg/d was around one-third that of people who didn't consume.

Vitamin E: Jacques et al*.,* found that people who consumed more than 35.7 mg/d of vitamin E had a 55% lower risk of cataracts than people who consumed less than 8.4 mg/d (Office of Dietary Supplements, National Institutes of Health [NIH], 2022; Hankinson et al*.,* 1992).

Carotenoids: According to Maci & Santos et al*.,* women with the highest intake of carotene consumption had a 30% lower rate of cataract surgery than women with the lowest intake of carotene. Rather, cataract surgery was linked to a reduction in food intake (Abdel-Aal et al*.,* 2013).

Xanthophyll: Xanthophylls may protect the eye from UV phototoxicity by quenching reactive oxygen species (ROS) and/or acting in other mechanisms (Moeller et al*.,* 2000; Fletcher, 2010).

Lutein and Zeaxanthin: Consumption of large amounts of lutein and zeaxanthin has been linked to a considerable reduction in the risk of cataracts (upto 20%). Lutein and its stereoisomer zeaxanthin, xanthophyll carotenoids, may play a key role in maintaining normal visual function. (Abdel-Aal et al., 2013; Moeller et al., 2000; Fletcher et al., 2010).

Antioxidant vitamins C and E, as well as the carotenoids lutein and zinc, are part of the lens and retina's antioxidant defense system, and epidemiological research on their links to cataracts is conflicting (Thiagarajan & Manikandan*,* 2013). Curcumin, vitamin C, and vitamin E are 3 natural substances with anti-cataract and antioxidant properties (refer Table 2). For a greater defense against free radicals, these antioxidants can be supplemented in the diet. Curcumin is well-known for its anti-cataract properties 64. (Camacho-Barcia et al*.,* 2017). A high dietary vitamin K1 intake was linked to a lower risk of cataracts. Participants who consumed the most dietary vitamin K1 had a decreased risk of cataracts than those who consumed the least (Jung et al*.,* 2022).

Ocular Surface Disease

The ocular surface disease can be broadly defined as a group of disorders that affect various components of the ocular surface (Yiu, 2014). The common result of the ocular surface disease is dysfunction of the ocular tear film and/or the integrity of the ocular surface. The ocular surface is the point of contact between the eye and the rest of the world (Rolando & Zierhut, 2001), (Wills Eye Hospital, n.d.). Damage to the eye's surface layers, such as the cornea and conjunctiva, is referred to as an ocular surface disease (Braakhuis et al*.,* 2017). Higher consumption of fruits and vegetables, as well as vitamin C and β-carotene, were found to have protective effects (refer Table 2) (Raman et al., 2016).

Antioxidants are absorbed through the food and created internally, and act as the first line of defense against oxidative stress (Chew, 2013). The primary antioxidants which protect eye functioning areascorbic acid, reduced glutathione, and superoxide dismutase-catalase (Guo et al., 2016). The cornea, central corneal epithelium, and lachrymal have a high level of ascorbic acid and play an important role in antioxidant protection in ocular health (Raman et al., 2016), (Chew, 2013). On the ocular surface system, curcumin has pleiotropic effects. Curcumin helped to restore ocular surface homeostasis by lowering ROS and inflammatory mediator expression (Guo et al., 2016).

Dry eye syndrome (DES)/disease (DED): Dry eye is a multifactorial disease (Giannaccare et al., 2019) of the tears and ocular surface that results in feelings of pain, visual impairment (Lemp & Foulks, 2007), and tear film instability with possible injury to the ocular surface' - according to the 2007 worldwide dry eye workshop (Stapleton et al., 2017). DED affects 5% to 30% of people over the age of 50years (Bhargava et al., 2013).

Omega-3 FA: The most common omega-3 FAs are alpha-linoleic acid (ALA), eicosapentaenoic acid (EPA), docosapentaenoic acid (DPA) and docosahexanoic acid (DHA). They have anti-inflammatory, anti-coagulant, and anti-hypertensive effects (Pellegrini et al., 2020). A recent randomized controlled trial (RCT) experiment found that a tear substitute comprising flaxseed oil and trehalose was more effective than an analog tear substitute in alleviating DED signs and symptoms when compared to an analog tear substitute without these two substances (Pellegrini et al., 2020). In RCT, upon daily intake of EPA 650mg + DHA 350mg and EPA 360 mg + DHA 240 mg showed significant improvement in symptom score, Schirmer test, and TBUT compared to placebo. Different doses of EPA and DHA showed significant improvement in dry eye symptoms, TBUT, Schirmer test, and corneal staining (Lemp & Foulks, 2007; Bhargava & Kumar, 2015; Bhargava et al., 2016; Oleñik et al., 2013; Sullivan et al., 2006). Thus omega-3FAs, particularly DHA, have been proven to ameliorate DES. (Alanazi et al., 2019). When Brudysec 1.5 pill 3times a day, a proprietary blend of vitamins, minerals, and essential FAs, was given for 3months, the signs and symptoms of DES improved (McCusker et al., 2016). Omega-3 FAs, Vitamin D, Vitamin C, and Vitamin B12, as well as other dietary supplements, have been shown to help with DED. Among these, scientific data supports the efficacy of omega-3 FAs supplementation in reducing dry eye disease occurrence.

Vitamin A: Vitamin A (retinol) is a biologically active form and acts as a precursor. In the developing world, VAD caused by malnutrition is one of the leading causes of preventable blindness (Wiseman et al., 2017). For several ocular surface illnesses such as DED, the improvement of ocular surface epithelial damage linked with oral or topical all-trans retinoic acid has been reported (Pellegrini et al., 2020). Furthermore, a recent study found that short-term vitamin A treatment enhances the quality of tears in patients with DED (Wiseman et al., 2017). Vitamin A ointment enhanced visual acuity, dry eye symptoms, and Schirmer scores (Pellegrini et al., 2020). Vitamin A is important for the ocular surface epithelium's proliferation and development (Hyon & Han, 2022), (Baltrusch, 2021). Vitamin A can also help with DED treatment by promoting tear formation and improving tear film quality. Systemic vitamin A therapy, both oral and parenteral, has been demonstrated to help reduce ocular surface damage and DED (Hyon & Han, 2022). Short-term oral vitamin A treatment (1500 mg/d for 3d) enhanced tear quality (Wiseman et al., 2017).

Vitamin B12: Vitamin B complexes are a collection of water-soluble vitamins with a lot of coenzyme activity that could help in maintaining ocular surface homeostasis and preventing DED (Belmonte et al., 2017). It has been used to treat neuropathic pain produced by peripheral nerve injury, and it appears to be a prevalent aspect of the condition (Ren et al., 2020). This shows that vitamin B12 insufficiency could be a factor in DED's neurosensory problems. Vitamin B insufficiency has been linked to DED in the population with NOP (neuropathic ocular pain), and micronutrient supplementation (refer Table 2) can help with DED, especially NOP-related DED. Oral vitamin B1 and mecobalamin, a type of vitamin B12, reduced both dry eye symptoms and signs. This report showed that the use of food supplements containing vitamins B1 and B2 resulted in an improvement in both DED symptoms and signs (Hyon & Han, 2022; Peponis et al., 2012).

Vitamin C: It's a water-soluble vitamin, which is required a variety of enzymes to work properly. Vitamin C is abundant in the tear film, indicating that the ocular surface has a high demand for antioxidant defense (Hyon & Han, 2022). Vitamin C and E administration was found to improve tear formation in diabetes patients (Pellegrini et al., 2020). This was linked to a considerable reduction in nitric oxide levels, which indicates that these chemicals are effective in reducing ocular surface oxidative stress (Doseděl et al., 2021). It possesses antioxidant, anti-inflammatory, and immune-modulatory properties, all of which can help prevent DED (Hyon & Han, 2022; Yoon et al., 2016).

Vitamin D: VAD is a fat-soluble vitamin that has recently been linked to the development of DED and reported as a potential treatment (Hwang et al., 2019). The effectiveness of vitamin D supplementation was observed in patients with DED. Yang et al. (2018) found a substantial reduction in dry eye symptoms following 2mo vitamin D treatments. The remedial action of tear substitutes is dependent on vitamin D serum levels, and oral vitamin D supplementation has been demonstrated to improve their efficiency in a synergistic manner (Zhang et al., 2019). It has a key function in regulating inflammation and immunological responses on the ocular surface, which can help alleviate dry eye signs and symptoms (Hyon & Han, 2022). Topical calcitriol reduced corneal inflammation and suppressed the production of inflammatory mediators, suggesting that vitamin D supplementation could be a viable treatment for DED (Niki & Abe, 2019).

Vitamin E: This is a series of fat-soluble compounds with anti-oxidative action. They may be useful for antioxidant defense on the ocular surface and in the treatment of DED (Serrano-Morales & De-Hita-Cantalejo, 2022). Eye drops containing 0.1% cross-linked hyaluronic acid, coenzyme Q10, and vitamin E demonstrated equivalent efficacy in treating tear film integrity and dry eye symptoms (Higuchi et al., 2010).

Selenium: The seleno protein is found in a variety of organs, even on the ocular surface, and its expression is reduced in DED patients, likely leading to ocular surface oxidative injury (Cejkova et al., 2008). In DED, selenoprotein levels in tears are reduced, and a lack of selenium leads to increased oxidative stress (Higuchi et al., 2016). According to Higuchi et al, selenium supports the synthesis of glutathione peroxidases and its function in the cornea, this helps restore the equilibrium between ROS and anti-oxidant scavengers (Dogru et al., 2007).

***Lactoferrin*:** The corneal epithelium is protected from UV irradiation by an iron-binding glycoprotein found in exocrine fluids, including tears (Pellegrini et al., 2020). Lactoferrin concentration was observed to be lower in DED, and oral supplementation improved symptoms significantly in patients with DED secondary to Sjögren's syndrome (Delgado et al., 2019).

***Polyphenols*:** A class of natural substances that are derived from plant secondary metabolites (Singla et al., 2019; Favero et al., 2021). They are promising in gaining attention for their ability to combat DED's key pathogenic mechanisms and alleviate its symptoms. They have a variety of anti-DED actions on the ocular surface (Dharmawansa et al., 2020). The reduction of pathogenic processes such as inflammation and oxidative stress, as well as the regulation of the tear film; have positive impacts on corneal cells (Dharmawansa et al., 2020). Polyphenols can directly interact with numerous enzymes, resulting in anti-inflammatory, and many other activities (Yu et al., 2018; Liu et al., 2017). The effects of topically applied polyphenolic compounds on DED have therapeutical effects against the most common DED injuries and symptoms (Dharmawansa et al., 2020).

Curcumin: A polyphenol extracted from *Curcuma longa*, a spice and flavoring ingredient, is widely used in Asian cuisine. Curcumin affects several cell signaling pathways, according to a current substantial study, with anti-inflammatory, antioxidant, anti-angiogenic, wound healing, and antibacterial effects (Tsubota et al., 2020; Oh et al., 2015).

Flavonoids: A class of polyphenolic secondary metabolites found in plants. Anti-inflammatory, immunomodulatory, and antioxidative activities are all present (Panche et al., 2016). Topical administration of quercetin enhanced tear volume, corneal regularity, and goblet cell density of dry eye and is associated with reduction of inflammation in the lacrimal gland (Majumdar & Srirangam, 2010).

Ocular disease: Bioflavonoids (flavones, flavanols, flavanones, flavonols, isoflavones, anthocyanidins) have a variety of pharmacological activities that can help prevent or treat ocular illnesses that cause vision loss. Flavonoids can operate on a variety of mechanisms or aetiological elements that contribute to the development of numerous vision-threatening ocular illnesses (Ozen et al., 2017). Due to numerous studies reporting that polyphenols are effective and safe for treating the pathological mechanisms of this ocular surface disease, future studies should confirm and extend the evidence of polyphenol efficacy in clinical practice against dry DED and aid in the development of new ophthalmic drugs (Raman et al., 2016).

Dry Eye syndrome/Disease: They are less common, and linked to vision-threatening consequences (Lemp & Foulks, 2007). Micronutrients derived from food or nutraceutical products influence the morphology and function of ocular surface components through several metabolic processes. Vitamin deficiency has an increased risk of DED, and vitamin supplementation may be an effective DED treatment. Vitamins C and D are critical for maintaining ocular surface homeostasis, while vitamin B12 has an important role in DED ("Nutritional amblyopia," n.d.). The potential protective impact of polyphenols and flavonoids on the ocular surface was examined. Omega-3 FAs from food and supplementation can treat DED. More clinical research is needed to determine the safety and efficacy of supplementing with other micronutrients and nutraceuticals (Peponis et al., 2012). Finally, a vast range of dietary components appears to have beneficial impacts on the health of the ocular surface.

Nutritional Amblyopia

Nutritional amblyopia is poor vision caused by a vitamin B-complex deficit in the diet (thiamine). The retinal capillaries become constricted and peripheral vision is decreased in quinine amblyopia. A diet rich in thiamine, folic acid, and vitamin B12 may help to reverse this illness. This disorder is caused by insufficient nutrition and has been seen predominantly in alcoholics and people who have had severe nutritional deprivation (Jefferis & Hickman, 2019; Langan & Goodbred, 2017).

Signs and symptoms of specific or combination B vitamin deficiencies involving thiamin, niacin, folate, vitamin B12, and riboflavin can be found on the skin, mucosa, neurological, gastrointestinal, and hematological levels (Semba, 2007; Peponis et al., 2012). In many industrialized countries, the incidence of nutritional amblyopia has decreased as a result of increased socioeconomic standards and hygiene, improved nutrition understanding, and obligatory fortification of specific foods with B vitamins (Peponis et al., 2012; Parrott et al., 2017). The most common treatment for nutritional amblyopia is to eat a balanced diet rich in vitamin B-complex foods (Nguyen et al., 2012). Low folate status in adults is linked to cognitive impairment as people age, which can have major effects on eye vision (Jefferis & Hickman, 2019). In reality, it's linked to nutritional amblyopia, optic disc pallor, disc atrophy, and a slow loss of eyesight (Roda et al., 2020).
With the increased consumption of nutrient-dense foods such as vitamin B (thiamine, niacin, and cobalamin) or fortified vitamins. In many industrialized countries, the incidence of nutritional amblyopia has reduced (Nguyen et al., 2012). Low folate status in adults is linked to nutritional amblyopia, hence foods high in folate (refer Table 2) should be consumed (Roda et al., 2020).

Nutritional Optic Neuropathy

Nutritional optic neuropathy results in the reduction of central visual acuity and contrast sensitivity that is bilateral, symmetrical, and progressive. This is an uncommon disorder that causes painless vision loss (Roda et al., 2020). Vitamin B12, Vitamin B1, folic acid, and copper deficits are common in bariatric surgery (Calderón-Ospina & Nava-Mesa, 2020) and a vegan diet become more popular. Nutritional optic neuropathy is the major cause of blindness in low- and middle-income countries, and it is a global health problem (Roda et al., 2020). As coenzymes for enzymatic reactions in numerous biological systems, vitamins of the B group are vital for maintaining the health of the nervous system, including the visual nerve. Vitamin B12, Vitamin B6, and Vitamin B1, generally known as neurotrophic vitamins, are necessary for the nervous system's function, particularly the health of the optic nerve (Ota et al., 2020).

Vitamin B1 (thiamine): Vitamin B1 is absorbed in the GI tract and stored as thiamine diphosphate in human tissues. Thiamine deficiency causes selective neuronal cell death through multiple pathways (Roda et al., 2020). The most common risk factors for thiamine deficiency are alcoholism, unbalanced eating, bariatric surgery, hyperthyroidism, and pregnancy (Gratton & Lam, 2014). Optic neuropathy is an uncommon symptom of VitaminB1 deficiency that is usually bilateral, severe, and accompanied by enlargement of the optic disc (Bailey et al., 2015).

Vitamin B9 (folic acid): A water-soluble B vitamin that is usually found in foods in the polyglutamate form. Because it is scarce, the oxidized monoglutamate form (folate) is available in fortified foods and nutritional supplements (Roda et al., 2020). Due to low food intake and drunkenness, folic acid insufficiency is linked to nutritional deficiencies, reduced absorption, and loss or increased needs (De Silva et al., 2008). A relationship has been shown between a lack of serum folate and the development of this condition. Progressive visual loss results from the deficiency, which usually presents as a painless central scotoma, either bilaterally or unilaterally, and changes in color perception and dyschromatopsia (Briani et al., 2013).

Vitamin B12 (cobalamin): A water-soluble vitamin, wherein long-term nutritional deprivation was observed in low-income nations, as well as poor bioavailability or absorption interference – the main causes of vitamin B12 deficiency (Roda et al., 2020). Hematological manifestations, gastrointestinal manifestations, and neurological manifestations are all symptoms of VitaminB12 deficiency (paresthesia, ataxia, peripheral neuropathy), (Chan et al., 2018). Optic neuropathy is a sign of cobalamin insufficiency that can occur before hematologic problems (Lazarchick, 2012).

Copper: Copper is a trace element that is essential for an organism's oxidative metabolism. Adults have a total body copper concentration of 100–150 mg. Copper insufficiency caused by a lack of dietary intake is extremely uncommon (Roda et al., 2020; Yarandi et al., 2014). It is more commonly associated with malabsorption and malabsorption syndromes such as inflammatory bowel disease, cystic fibrosis, and celiac disease. Copper deficiency has been linked to hematologic disorders (Rapoport & Lavin, 2016). Copper deficiency has recently been linked to optic neuropathy and vision loss (Schwartz et al., 2020).

The severity of the condition and the amount of time that has passed between the onset of symptoms and the start of micronutrient supplementation determine the prognosis. The majority of the time, visual recovery is complete; however, if the deficiency is chronic, the damage causes optic atrophy (Roda et al., 2020; Ota et al., 2020).

Nutritional optic neuropathy is one of the uncommon causes of visual loss. Micronutrient deficiency, specifically vitamin B1, vitamin B9, vitamin B12, and copper deficiency, should be taken care of in patients with bilateral, progressive, and symmetrical visual loss because early identification and treatment can improve the prognosis (Bailey et al., 2015; Briani et al., 2013; Yarandi et al., 2014). Because visual impairment has serious consequences for both individuals and the healthcare system, all patients at risk of developing nutritional optic neuropathy should receive vitamin supplementation (Roda et al., 2020).

Retinitis Pigmentosa

The term 'retinitis pigmentosa' (RP) refers to a group of disorders marked by the gradual degeneration of the retinal photoreceptors (light-sensing cells) and the neighboring RPE cells. RP affects about one in every 4000 people worldwide, including 100,000 people in the U.S. (Hartong et al., 2006) The effectiveness of numerous supplements like vitamin A, DHA, and lutein in delaying disease progression is still unknown, but it is a promising therapy option (Hartong et al., 2006; Openshaw et al., 2008). Supplementing with vitamin A palmitate may help to delay the progression of the disease123. (Berson et al., 2018). According to recent research, effective vitamin A supplementation can delay blindness by upto10y in some patients at different stages of the disease (Piano et al., 2021; Berson et al., 2018).

Vitamin A: Oral vitamin A administration is thought to potentially reduce the loss of retinal function in people with RP and normal liver function, according to a case-control study of children with RP (National Institutes of Health, 2022). These data support the use of an age-appropriate vitamin A dose in the treatment of most children with typical types of RP (National Institutes of Health, 2022). A favorable effect of 15000 IU/d of vitamin A and imply that 400 IU/d of vitamin E has a deleterious influence on the progression of RP (Zhao et al., 2019). The current study backs up the theory that a daily 15000 IU vitamin A pill will decrease the growth of typical forms of RP as measured by ERG (Electroretinography) testing (Rotenstreich et al., 2013; Zhao et al., 2019). In terms of vitamin E, a daily dose of 400 IU could alter the progression of RP retinal degeneration (Zhao et al., 2019). A potential RP treatment is any vitamin or mineral that has been shown to have antioxidant properties in vivo or is a key component of an antioxidant enzyme found in the retina (Pasantes-Morales et al., 2002).

β-carotene: According to Rotenstreich et al the groups were randomly assigned to receive either 300 mg of the 9-cis-carotene-rich alga*Dunaliellabardawil* or 300 mg of a placebo (starch). The treatment period lasted 90 days: Treatment improved retinal function in RP patients in both dark-adapted maximal b-wave and light-adapted b-wave. Furthermore, 300 mg/d 9-cis-carotene therapy resulted in a significant improvement in objective rod-cone functions (Rotenstreich et al., 2013).

Vitamin E: Vitamin E acts as antioxidant property, which protects photoreceptor structure in vitro and in vivo. For 3 to 6 years, Pasantes-Morales et al a daily therapy of taurine 1 g, vitamin E 400 mg, and diltiazem 30 mg improved visual acuity by 24% in control patients and 40% in taurine and vitamin E treated patients. In the group that received the taurine/vitamin E treatment for up to 6 years, there were long-term benefits (refer Table 2). Taurine and vitamin E were found to have a protective effect against visual field loss in this study (Zhao et al., 2019; Korobelnik et al., 2017).

Lutein: Lutein, a carotenoid, has been suggested as a viable treatment agent for people with RP who want to keep their vision (Bahrami et al., 2006). According to Bahrami et al., and Romeu et al., the groups were given lutein capsules of 10-30 mg/d for 12 wk or a placebo for 24 wk, and all participants were given multivitamin supplementation: this showed that lutein slows the loss of mid-peripheral visual field on average among non-smokers with RP taking vitamin A.

In children with RP, supplementing with vitamin A palmitate was linked to a delayed reduction of cone ERG amplitude (National Institutes of Health, 2022). Based on these findings and analysis of ERG amplitude decline as a function of total vitamin A intake, it is recommended that most adult patients with the common forms of RP take a vitamin A supplement of 15000 IU/d under the supervision of an ophthalmologist (Rotenstreich et al., 2013; Zhao et al., 2019). Vitamin A has been linked to retinal photoreceptor function; DHA, which is found within photoreceptor cell membranes, may play a functional role in preventing the progression of RP, according to studies (Pasantes-Morales et al., 2002).

FUTURE RESEARCH/RECOMMENDATION

Fruit and vegetable-rich diets appear to protect against cataracts, glaucoma, and AMD, whereas meat and diets high in nutrients increase the risk of oxidative stress-related eye disorders. Furthermore, increased dietary vitamin C and β-carotene intake combined with lower dietary cholesterol intake may help to prevent oxidative stress-related eye disorders (Raman et al., 2016). Meat consumption, on the other hand, tended to enhance the risk of AMD and cataracts, when ingested often and in substantial amounts (Carvalho et al., 2015), (Boeing et al*.,* 2012). Antioxidants in the diet play an important role in reducing oxidative stress by blocking oxidative processes and eliminating free radical intermediates (World Health Organization, 2014). In a community with a similar case-to-case distribution as our study, dietary counseling along these lines may contribute to public health guidelines for lowering the risk of cataracts, glaucoma, and AMD (Raman et al*.,* 2016). Dietary counseling may contribute to public health guidelines for lowering the risk of cataracts, glaucoma, and AMD (Raman et al*.,* 2016). Additional nutritional assessments for the treatment of cataracts and AMD progression may be included in future evaluations. According to research, antioxidants and other essential nutrients may reduce the risk of cataracts and macular degeneration. Specific antioxidants may also provide additional benefits; for example, vitamin A may help prevent or alleviate blindness, while vitamin C may help prevent or alleviate glaucoma. Omega-3 essential FAsin reducing dry eye symptoms to prevent AMD. Vitamins and minerals can be easily included in a healthy diet to improve eye health, or supplements can be added to one's diet. Lutein and zeaxanthin may play a role in visual function, according to scientific data (McCusker et al*.,* 2016).

Maintaining healthy nutrition has an impact on one's quality of life, thus it's critical to protect one's eye health. While excellent overall health necessitates the consumption of a wide range of vitamins and minerals, optimal eye health necessitates the consumption of a limited number of vitamins and minerals. This paper has discussed the function of nutrients including vitamins, multivitamin supplements, carotenoids, xanthophyll, minerals, curcumin, anti-oxidants, lactoferrin, polyphenols, omega-3 fatty acids, and curcumin in the prevention of various eye conditions. These nutrients have been demonstrated to be beneficial to eye health. Fortunately, there are numerous foods and supplements available with critical nutrients for the prevention of eye-related problems. With strict adherence, one can achieve both improved general and eye health.

Poor nutrition in humans can result in deficiency-related diseases such as blindness, anaemia, scurvy, preterm birth, stillbirth, and cretinism. One of the most common causes of blindness in the world is vitamin A deficiency (VAD) (American Academy of Ophthalmology, 2022). The light-sensing cells in your eyes, generally known as photoreceptors, require this vitamin to function properly. A lack of vitamin A can cause night blindness and dry eyes. Vitamin A is only present in animal-derived diets; however certain plant-based carotenoids can be converted into vitamin A by the human body. Zinc is an essential nutrient for proper eye function. According to a study, vitamins may help older people delay the onset of macular degeneration (Piano et al*.,* 2021). A high lutein and zeaxanthin consumption may lower the chances of developing eye illnesses like macular degeneration and cataracts. Getting enough long-chain omega-3 fatty acids (FAs); Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) from oily fish or supplements may lower the chance of developing a variety of eye problems, including dry eyes. Even primrose oil has a lot of gamma-linolenic acids (GLA), which may help with dry eye symptoms. Vitamin C is essential for eye health, and taking enough of this antioxidant could help prevent cataracts (McCusker et al*.,* 2016). Vitamin E insufficiency can cause vision loss and blindness (Solebo et al*.,* 2021).

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