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Impact of vegetarian and vegan diets on visual acuity and ocular health – a literature review

Wpływ diety wegetariańskiej i wegańskiej na ostrość wzroku i zdrowie oczu – przegląd literatury

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Abstract

Introduction and objective. Vegetarian and vegan diets are increasingly adopted for health, environmental, and ethical reasons. These dietary patterns are rich in antioxidants, such as lutein and zeaxanthin, which may support retinal health. However, exclusion of animal-derived foods may increase the risk of deficiencies in nutrients essential for visual function, particularly vitamin B12, iron, long-chain omega-3 fatty acids, and vitamin A.
Brief description of the state of knowledge. The aim of the review is to summerise current evidence on the relationship between vegetarian and vegan diets and visual acuity as well as overall ocular health, with emphasis on both protective mechanisms and deficiency-related risks. A narrative literature review was conducted using PubMed/PMC, Web of Science, and Scopus. English-language publications from 2001 to 2025 were screened using keywords related to plant-based diets, visual acuity, ocular diseases, and selected micronutrients.
Summary. Higher intake of lutein and zeaxanthin is associated with increased macular pigment and may lower the risk of late age-related macular degeneration and cataract formation in some populations. In contrast, inadequately planned vegetarian or vegan diets may lead to vitamin B12 and iron deficiency, which have been linked to nutritional optic neuropathy and retinal vascular changes, as well as low EPA and DHA status that may adversely affect retinal function. Insufficient vitamin A intake may impair the visual cycle and contribute to night blindness and ocular surface disorders. Well-planned plant-based diets can support ocular health; however, careful attention to vitamin B12, iron, omega-3 fatty acids, and vitamin A intake is necessary. Regular monitoring and appropriate supplementation or fortification may help reduce the risk of preventable vision impairment.

Key words

iron, omega-3 fatty acids, vitamin B12, visual acuity, vegetarian diet, vegan diet

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Streszczenie

Wprowadzenie i cel pracy. Dieta wegetariańska i wegańska staje się coraz bardziej popularna ze względów zdrowotnych, środowiskowych i etycznych. Tego typu dieta jest bogata w przeciwutleniacze, takie jak luteina i zeaksantyna, które mogą wspomagać zdrowie siatkówki. Jednak wykluczenie produktów pochodzenia zwierzęcego może zwiększać ryzyko niedoborów składników odżywczych niezbędnych dla prawidłowego funkcjonowania wzroku, w szczególności witaminy B12, żelaza, długołańcuchowych kwasów tłuszczowych omega-3 i witaminy A.
Opis stanu wiedzy. Artykuł zawiera podsumowanie aktualnych dowodów na związek między dietą wegetariańską i wegańską a ostrością wzroku oraz ogólnym stanem zdrowia oczu, ze szczególnym uwzględnieniem mechanizmów ochronnych i zagrożeń związanych z niedoborami składników odżywczych. Przeprowadzono przegląd literatury przy użyciu baz PubMed/PMC, Web of Science i Scopus. Angielskojęzyczne publikacje z lat 2001–2025 zostały przeanalizowane przy użyciu słów kluczowych związanych z dietą roślinną, ostrością wzroku, chorobami oczu i wybranymi mikroelementami.
Podsumowanie. Wyższe spożycie luteiny i zeaksantyny wiąże się ze zwiększoną ilością barwnika plamki żółtej oraz może zmniejszać ryzyko późnego AMD i zaćmy w niektórych populacjach. Niewłaściwie zaplanowana dieta wegetariańska lub wegańska może jednak prowadzić do niedoborów witaminy B12, żelaza, kwasów omega-3 (EPA, DHA) i witaminy A, co może skutkować neuropatią wzrokową, zmianami naczyniowymi siatkówki, zaburzeniami funkcji siatkówki oraz upośledzeniem cyklu widzenia. Dobrze zbilansowana dieta roślinna może wspierać zdrowie oczu, pod warunkiem monitorowania podaży kluczowych składników i ewentualnej suplementacji.

Słowa kluczowe

witamina B12, żelazo, dieta wegetariańska, kwasy tłuszczowe omega-3, ostrość wzroku, dieta wegańska

INTRODUCTION

Vegetarian and vegan diets have gained global popularity due to evidence supporting their benefits in reducing the risk of cardiovascular diseases, type 2 diabetes, and certain cancers [1, 2]. These diets are characterised by the partial (vegetarian) or complete (vegan) exclusion of animal-derived products, leading to a high intake of antioxidants, such as lutein and zeaxanthin, which support ocular health [3, 4]. Although both dietary patterns are classified as plant-based, they differ in the extent of exclusion of animal-derived products, which has important nutritional implications. Vegetarian diets may include dairy products and/or eggs, whereas vegan diets eliminate all animal-derived foods. Consequently, the risk of specific nutrient deficiencies varies between these approaches. In particular, vitamin B12 deficiency is predominantly associated with strict vegan diets in the absence of appropriate supplementation, while iron deficiency may occur in both vegetarians and vegans due to the lower bioavailability of non-heme iron from plant sources. Additionally, long-chain omega-3 fatty acids (EPA and DHA) are typically limited in vegan diets, and vitamin A status depends on the efficiency of conversion from provitamin A carotenoids [5–7]. However, restricting animal products may result in deficiencies of key nutrients, including vitamin B12, iron, omega-3 fatty acids, and vitamin A, which are essential for the visual system, particularly visual acuity [5, 6].

Visual acuity, defined as the ability to discern fine details in visual images, is a critical measure of ocular health and can be impaired by nutritional deficiencies leading to conditions such as optic neuropathy, central retinal vein occlusion (CRVO), age-related macular degeneration (AMD), or cataracts [7–10]. Plant-based diets, rich in carotenoids, may mitigate the risk of these conditions, but inadequate dietary planning increases the likelihood of deficiencies that can adversely affect vision.

OBJECTIVE

The aim of the review is to analyse the literature on the impact of vegetarian and vegan diets on visual acuity, offering insights into the importance of balanced nutrition in ocular disease prevention. The review also covers clinical cases highlighting the risks of nutrient deficiencies in plant-based diets and provides a detailed discussion of nutrients supporting ocular health, such as lutein and zeaxanthin.

MATERIALS AND METHOD

This study was designed as a narrative literature review and therefore did not follow PRISMA reporting guidelines. To explore the relationship between plant-based diets and eye health, a comprehensive literature review was conducted using databases such as PubMed, PMC, Web of Science, and Scopus. The search focused on English-language articles published between 2001–2025. Key words included such terms as: ‘vegetarian diet’, ‘vegan diet’, ‘visual acuity’, ‘ocular health’, ‘vitamin B12’, ‘iron’, ‘omega-3 fatty acids’, ‘lutein’, ‘zeaxanthin’, ‘vitamin A’, ‘retinopathy’, ‘central retinal vein occlusion’, ‘age-related macular degeneration’, and “’ptic neuropathy’. Also included were clinical trials, case reports, systematic reviews, and meta-analyses that examined how plant-based diets may influence ocular health – particularly visual acuity. Studies that were not relevant to the topic, lacked methodological rigour, or were not published in English, were excluded.

The analysis focused on both the potential benefits of high antioxidant intake and the risks associated with nutrient deficiencies. Special attention was paid to clinical findings and biological mechanisms, highlighting case reports that showed how deficiencies could impact eye health. Additionally, nutrients commonly found in vegetarian diets – such as lutein and zeaxanthin – and their role in maintaining visual function were closely examined.

RESULTS

Benefits of plant-based diets for ocular health. Plant-based dietary patterns are characterised by a high intake of bioactive compounds with antioxidant and anti-inflammatory properties, which may exert protective effects on ocular tissues. Among these, carotenoids – including lutein and zeaxanthin – are of particular importance due to their selective accumulation in the macula, where they contribute to the filtration of blue light and reduction of oxidative stress, thereby supporting retinal function and visual acuity.

Vegetarian and vegan diets provide a wide range of nutrients and phytochemicals beneficial for eye health. These include antioxidant vitamins such as vitamin C and vitamin E, as well as such trace elements as zinc, which collectively contribute to the protection of photoreceptor cell membranes, modulation of oxidative damage, and maintenance of retinal integrity [4]. In addition, plant-based diets are rich in flavonoids, polyphenols, and essential fatty acids, which may further support ocular microcirculation, reduce inflammation, and enhance overall visual function.

Vegetarian and vegan diets are rich in antioxidants, particularly carotenoids, such as lutein and zeaxanthin, which accumulate in the macula of the retina, protecting it from oxidative stress and blue light [3, 4]. The research by Grudziński et al. revealed the pivotal role of lutein and zeaxanthin in the safeguarding of the retina from oxidative damage by means of the absorption of blue light and the neutralisation of free radicals, a process of particular importance in the prevention of age-related macular degeneration (AMD) [3]. The research highlighted that individuals adhering to plant-based diets, rich in these carotenoids, may achieve higher macular concentrations of lutein and zeaxanthin, leading to improved visual acuity and reduced risk of age-related ocular diseases. For instance, the AREDS2 study found that supplementation with lutein (10 mg/day) and zeaxanthin (2 mg/day) over five years reduced AMD progression by 26% in high-risk individuals [11]. Furthermore, high intake of lutein and zeaxanthin is associated with a lower risk of AMD of about 40% in both women and men [10]. A meta-analysis confirmed that diets rich in carotenoids may reduce the risk of age-related ocular diseases, making plant-based diets potentially beneficial for ocular health [12]. Specifically, Ma et al. conducted a systematic review and meta-analysis of six longitudinal cohort studies, finding that while dietary lutein and zeaxanthin intake was not significantly associated with a reduced risk of early AMD (pooled RR 0.96; 95% CI

0.78–1.17), it significantly reduced the risk of late AMD (pooled RR 0.74; 95% CI 0.57–0.97) and neovascular AMD (pooled RR 0.68; 95% CI 0.51–0.92), suggesting a protective role for plant-based diets rich in these carotenoids [12]. Furthermore, a study by the Women's Health Initiative revealed a link between following dietary guidelines more closely and a lower chance of developing nuclear cataracts in postmenopausal women. The closer a woman's diet to the top of the Healthy Eating Index score, the lower the risk of cataracts [4].

In addition to lutein and zeaxanthin, increasing scientific attention has been directed toward other plant-derived bioactive compounds with potential protective effects against age-related macular degeneration (AMD). Carotenoids such as crocin, along with polyphenols, are among the most extensively studied natural compounds, and their synergistic effects may contribute to improved retinal outcomes [13]. Medicinal plants including saffron, Ginkgo biloba, bilberry, and turmeric have been reported to exhibit beneficial properties, largely attributed to their antioxidant and anti-inflammatory activity. Notably, turmeric and Ginkgo biloba have also demonstrated anti-angiogenic effects, highlighting their potential therapeutic relevance in AMD management [13].

From a biochemical perspective, xanthophylls represent a subclass of carotenoids characterised by the presence of hydroxyl groups, which increase their polarity compared to carotenes. This structural feature facilitates their selective accumulation in ocular tissues, particularly in the macula, where they play a crucial role in protecting the retina against photochemical damage through antioxidant and anti-inflammatory mechanisms [14]. Importantly, xanthophylls cannot be synthesised *de novo* in the human body and must be obtained through diet, with major sources including spinach (Spinacia oleracea), kale (Brassica oleracea), and peppers (Capsicum annuum) [14]. Additionally, β-cryptoxanthin, another dietary carotenoid, may serve as a provitamin A compound.

Clinical evidence further supports the role of carotenoids in AMD prevention. The AREDS1 study demonstrated that supplementation with antioxidants and zinc reduced the progression to advanced AMD by approximately 25%. Subsequent modifications, including the addition of lutein and zeaxanthin, resulted in an additional reduction in disease progression, while replacing β-carotene with these xanthophylls improved safety and further reduced progression rates [15]. These findings reinforce the importance of carotenoid-rich diets, particularly plant-based dietary patterns, in maintaining retinal health and reducing the risk of advanced ocular disease.

Vitamin C and E. Vitamins C and E are key antioxidant nutrients that contribute to ocular protection through complementary mechanisms. Vitamin C enhances the activity of other antioxidants, including lutein, thereby strengthening the defence of the lens against oxidative damage and reducing the risk of cataract formation [4]. Vitamin E plays an essential role in maintaining the structural integrity of photoreceptor cell membranes, while zinc facilitates the transport of carotenoids to the retina, supporting visual function [16]. Dietary sources of vitamin C are abundant in plant-based foods, particularly fruits and vegetables such as citrus fruits, berries, leafy green vegetables, peppers, and traditional sources like Amla (Emblica officinalis), which has been shown to support ocular vascular health and reduce the risk of retinal haemorrhages [17]. Vitamin E is primarily found in nuts, seeds, whole grains, and vegetable oils, including sunflower and wheat germ oil, as well as in green leafy vegetables.

Epidemiological and clinical evidence supports the protective role of vitamin C in ocular diseases. A meta-analysis demonstrated that high dietary intake of vitamin C was associated with a significantly reduced risk of cataract development, particularly nuclear cataracts [18]. Similarly, longitudinal cohort data indicate that higher vitamin C consumption is linked to a decreased progression of lens opacification over time [19]. Furthermore, large-scale clinical trials, such as the AREDS study, have shown that supplementation with antioxidant vitamins, including vitamins C and E, in combination with carotenoids and zinc, can reduce the risk of progression to advanced age-related macular degeneration [20, 21].

However, it should be noted that excessive intake of antioxidant supplements beyond recommended levels may be associated with adverse effects, including an increased risk of kidney stones in the case of vitamin C, and potential systemic complications related to high-dose vitamin E supplementation [22]. Therefore, obtaining these nutrients through a balanced diet rich in plant-based foods remains the preferred strategy for supporting ocular health.

Lipids. Lipids are essential for ocular physiology, particularly in maintaining retinal microvascular integrity and ocular surface homeostasis. Wang et al. reported that individuals adhering to plant-based diets exhibit reduced retinal vessel calibre and tortuosity, which may indicate improved retinal microcirculation and vascular function [1, 2]. These effects are likely attributable to the low saturated fat and high dietary fibre content characteristic of such diets, contributing to improved lipid profiles and enhanced glycaemic control, thereby reducing the risk of diabetic retinopathy and other vascular retinal disorders.

In addition to these systemic effects, plant-derived lipids may exert direct anti-inflammatory properties. Linum usitatissimum (flaxseed), a plant rich in essential fatty acids such as α-linolenic acid (omega-3) and γ-linolenic acid (omega-6), has been investigated for its potential therapeutic applications. Oral supplementation with flaxseed oil (1–2 g/day) has been shown to reduce inflammatory markers and improve clinical symptoms in patients with dry eye disease associated with Sjögren's syndrome [23]. In addition to flaxseed, other plant-derived sources of beneficial lipids include oils such as olive and hemp oil, which provide polyunsaturated fatty acids and may contribute to improved ocular surface stability and reduced inflammation [24].

These findings indicate that plant-based sources of polyunsaturated fatty acids may support both retinal and ocular surface health, underscoring their relevance in dietary strategies for the prevention and management of ocular diseases [25]. Despite these beneficial effects, plant-based diets may be limited in long-chain omega-3 fatty acids (EPA and DHA), which are crucial for retinal function, highlighting the importance of adequate dietary planning, as discussed in section 3.2.3.

Table 1. Beneficial components of plant-based diets and ocular effects

Nutrient	Main Dietary Sources	Mechanism of Action	Ocular Effects	References
Carotenoids (lutein, zeaxanthin)	Leafy green vegetables (spinach, kale), peppers	Blue light filtration, antioxidant activity, reduction of oxidative stress	Reduced risk of AMD, improved visual acuity	[10–12]
Vitamin C	Citrus fruits, berries, peppers, leafy greens, Amla	Enhances antioxidant defence, supports lens protection	Reduced risk of cataracts, protection against oxidative damage	[17–19]
Vitamin E	Nuts, seeds, vegetable oils, whole grains	Maintains photoreceptor membrane integrity	Protection of retinal cells, reduced oxidative damage	[16,20]
Lipids (plant-derived fatty acids)	Flaxseed, plant oils	Anti-inflammatory effects, improved microcirculation	Improved retinal vascular health, reduced dry eye symptoms	[23–25]
Anthocyanins	Berries, grapes, aubergine	Improves microcirculation, antioxidant effects	Enhanced retinal blood flow, potential improvement in visual acuity	[26,27]
Flavonoids (e.g. quercetin)	Tea, apples, onions, leafy vegetables	Anti-inflammatory, antioxidant, anti-fibrotic effects	Protection against ocular surface diseases and inflammation	[29–31]
Vitamin A (provitamin A carotenoids)	Carrots, plant-derived carotenoids	Supports phototransduction and retinal integrity	Protection against retinal degeneration	[36,37]

Anthocyanins and flavonoids. Anthocyanins, a subclass of flavonoids, have attracted considerable attention due to their potential beneficial effects on ocular health, particularly through their influence on retinal microcirculation and visual function. These compounds have been shown to improve blood flow within retinal vessels and may contribute to enhanced visual acuity [26]. Rich dietary sources of anthocyanins include berries such as bilberries, blueberries, blackberries, and blackcurrants, as well as aubergine and purple grapes [27].

Flavonoids are widely distributed natural antioxidants found in a variety of foods, including green leafy vegetables, tea, apples, and onions [28]. Among them, quercetin, a prominent member of the flavonol subclass, has been extensively investigated for its biological activity. Similar to other flavonoids, quercetin exhibits strong antioxidant properties, including free radical scavenging, metal ion chelation, and inhibition of lipid peroxidation [29]. In addition, it demonstrates anti-inflammatory and anti-fibrotic effects, as confirmed in both *in vitro* and *in vivo* studies across multiple tissues [30].

In the context of ocular health, quercetin has shown promising therapeutic potential, particularly in diseases affecting the ocular surface, such as dry eye disease, keratoconus, ocular surface inflammation, and corneal neovascularisation [30]. Its anti-inflammatory effects are largely mediated through downregulation of the NF-κB signalling pathway, as demonstrated in both experimental and clinical models [31–33]. Furthermore, topical application of quercetin has been associated with improved tear production and restoration of corneal surface integrity without inducing epithelial damage [29]. Additional studies suggest that quercetin may modulate cellular metabolism in corneal stromal cells, reducing oxidative stress and supporting more efficient energy production, which may be relevant in the pathophysiology of keratoconus [30, 34, 35].

Overall, flavonoids, and particularly anthocyanin-rich foods and quercetin, represent promising dietary and therapeutic components that may support ocular health through their antioxidant, anti-inflammatory, and vasoprotective properties [30].

Vitamin A. Vitamin A and its dietary precursors are essential for maintaining normal visual function, particularly through their role in phototransduction and retinal integrity. Plant-based diets provide provitamin A carotenoids, with carrots representing one of the richest sources of β-carotene, a key precursor of vitamin A. In addition to carotenoids, carrots also contain flavonoids, contributing to their antioxidant properties and potential protective effects on ocular tissues [36].

Experimental evidence further supports the role of vitamin A in retinal health. In a study conducted by El-Mansi et al., diabetes-induced retinal damage in Wistar rats was characterised by reduced retinal thickness, increased apoptosis of ganglion cells, synaptic degeneration, and enhanced neovascularisation, accompanied by elevated oxidative stress and disrupted neurotransmitter balance [37]. Supplementation with vitamin A and carrot root extract was shown to mitigate these pathological changes, restoring antioxidant enzyme activity, reducing lipid peroxidation, and preserving retinal structure and function. These findings suggest that vitamin A and carotenoid-rich plant sources may exert protective effects against retinal degeneration, particularly under conditions of metabolic stress [37]. It should be noted that while plant-based diets provide provitamin A carotenoids, the efficiency of their conversion to active vitamin A varies, which may increase the risk of deficiency in inadequately balanced diets, as discussed in section 3.2.4.

A structured summary of the key protective dietary components and their mechanisms of action is presented in Table 1.

Risks of nutrient deficiencies. Vegetarian and vegan diets, although beneficial for ocular health, may lead to deficiencies in key nutrients that adversely affect visual acuity. The following sections discuss the primary deficiencies and their consequences.

Vitamin B12. Vitamin B12, primarily found in animal-derived products, is essential for optic nerve health, myelination of nerve fibres, and retinal ganglion cell function [38]. Deficiency disrupts homocysteine metabolism, leading to vascular endothelial damage, oxidative stress, and optic neuropathy, manifesting as reduced visual acuity, visual field defects, and central scotomas [7, 9]. Cobalamin (vitamin B12) deficiency has been implicated in various ophthalmic conditions. It may contribute to optic neuropathy, with partial visual recovery possible following supplementation. Epidemiological studies have also identified a correlation between low B12 levels and a higher incidence of both early and late forms of age-related macular degeneration (AMD). Furthermore, emerging evidence links B12 deficiency to dry eye disease, particularly in cases involving neuropathic ocular pain. Supplementation, alongside conventional topical therapy, has been shown to improve symptoms in affected patients [39]. Pawlak et al. reported that 62–73% of vegans may experience vitamin B12 deficiency without supplementation, potentially increasing the risk of ocular complications such as optic neuropathy [40]. A longitudinal study by Rizzo et al. found that nearly 40% of vegans who did not take vitamin B12 supplements showed early signs of neuropathy [41]. Clinical manifestations included blurred vision, dyschromatopsia, and, in severe cases, irreversible optic atrophy [42]. Anaemia, particularly prevalent among women, has been associated with corneal and retinal abnormalities. Coşkun et al. demonstrated that patients with iron-deficiency anaemia (IDA) or combined IDA and vitamin B12 deficiency anaemia (B12DA), exhibit endothelial dysfunction and significantly reduced central corneal thickness compared to healthy controls [43].

Fortified plant-based foods, such as non-dairy milk (e.g., soy milk) or nutritional yeast, provide some B12, but their bioavailability is variable, necessitating supplementation with cyanocobalamin or methylcobalamin [5]. Strategies to mitigate deficiency include fortified breakfast cereals, plant-based meat analogues, and sublingual B12 supplements, which are critical for maintaining optic nerve integrity and preventing long-term visual impairment [40]. Regular monitoring of serum vitamin B12, methylmalonic acid, and homocysteine levels is recommended in individuals following vegetarian or vegan diets who may be at risk of deficiency [38]. However, intramuscular injections of 1,000 µg of cobalamin once weekly for up to four weeks are recommended only in patients with confirmed vitamin B12 deficiency, particularly when deficiency is severe or symptomatic [44].

Iron. Iron in the diet comes in two forms: heme iron, found in animal products, and non-heme iron, found in both plants and animals. Although heme iron makes up only about 10–15% of total intake in meat-eaters, it is absorbed much more efficiently (15–35%), and can account for over 40% of the iron the body actually absorbs [45]. Non-heme iron in plant-based foods has lower bioavailability compared to heme iron, elevating anaemia risk in vegetarians and vegans [46]. Iron is critical for oxygen transport, retinal metabolism, and erythropoiesis, with deficiency leading to microcytic anaemia, increasing the risk of central retinal vein occlusion (CRVO) and retinal hypoxia [8]. Pawlak R et al. reported that 25–40% of vegetarians and vegans, particularly women of reproductive age, have suboptimal iron status, with ferritin levels below 15 µg/L in severe cases [46]. Iron deficiency may lead to retinal microvascular alterations, including increased vessel tortuosity, retinal haemorrhages, and the presence of exudates, which in turn may impair visual acuity, as reported in clinical studies [8, 47]. Vegetarians can improve their iron status through diet and cooking habits. Many foods are fortified with iron-like cereals (some with up to 60 mg per 100 g)-and legumes such as soybeans and lentils provide up to 5 mg per 100 g cooked. Cooking in cast iron cookware has been shown to increase the iron content of food. However, its clinical relevance in preventing or treating iron deficiency remains limited and depends on multiple factors, including dietary composition and bioavailability [46]. A systematic review further suggests that while cooking in iron cookware may increase haemoglobin levels and reduce the prevalence of iron deficiency anaemia in certain populations, the magnitude of this effect is inconsistent across studies and influenced by factors such as food type, duration of use, and underlying health conditions [48]. Supplementation with ferrous sulphate (65 mg elemental iron/day) or chelated iron forms is recommended for deficient individuals, alongside regular monitoring of haemoglobin (target: 12–15 g/dl for women) and ferritin levels to prevent CRVO and other retinal complications [8]. Iron absorption improves with vitamin C-rich foods (e.g., citrus, berries) or juices consumed with meals. In contrast, its absorption may be significantly reduced by concurrent intake of calcium-rich foods or supplements, as well as beverages such as tea and coffee, which contain polyphenols that inhibit iron bioavailability [46].

Omega-3 fatty acids. Omega-3 fatty acids, in particular eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential for maintaining neuronal membrane fluidity and synaptic plasticity. In addition, docosahexaenoic acid (DHA), are vital for photoreceptor cell membrane integrity, retinal signal transduction, and anti-inflammatory processes. However, these long-chain fatty acids are typically scarce in vegan diets, which rely primarily on alpha-linolenic acid (ALA) from plant sources. The conversion rate of ALA to EPA and DHA in the human body is notably low [49].

Beyond nutritional deficiencies and antinutritional factors, the impact of vegan and vegetarian diets on neurological health is also mediated by their influence on inflammation and oxidative stress. These diets are generally associated with reduced systemic inflammation due to their high content of antioxidants and anti-inflammatory compounds, such as flavonoids, carotenoids, and polyphenols [50]. However, the limited intake of key anti-inflammatory nutrients, particularly omega-3 fatty acids like EPA and DHA, may counteract some of these benefits. These long-chain fatty acids are crucial for modulating neuroinflammation and preserving neuronal integrity [11], and they also play an important role in vision by supporting the health of the optic nerve and visual pathway. Lawrenson et al. reported that reduced DHA levels in individuals following a vegan diet are associated with lower retinal and contrast sensitivity, alongside an elevated risk of age-related macular degeneration (AMD) [51]. As DHA forms a substantial component of photoreceptor membranes, its deficiency may disrupt rhodopsin activity and impair visual signal transmission. Additionally, omega-3 fatty acids are increasingly recognised for their role in modulating retinal inflammation, which may help slow AMD progression [49, 51]. According to Klein et al., major dietary sources of EPA and DHA include oily fish, dairy, and meat; thus, vegans typically have lower intake and reduced plasma levels of these omega-3 fatty acids due to exclusion of such foods [52, 53]. To support adequate ALA intake, a well-balanced vegan diet should include plant-based sources, such as walnuts, chia seeds, and oils from flaxseed, rapeseed, and hemp [53]. Given the low conversion of ALA to EPA and DHA, optimising omega-3 intake is essential, with recommended daily ALA intakes of 1.1 g for women and 1.6 g for men [54]. Functional foods fortified with marine or algal-derived EPA/DHA-such as plant-based milks, juices, spreads, and snacks-can help bridge this gap [29].

Table 2. Nutrient deficiencies and their impact on ocular health

Nutrient Deficiency	Mechanism	Ocular Manifestations	Risk Factors (Plant-Based Diets)	Management	References
Vitamin B12	Impaired myelination, increased homocysteine → vascular damage	Optic neuropathy, visual field defects, central scotomas	Vegan diet without supplementation	Supplementation (oral or intramuscular), monitoring biomarkers	[5, 38–44]
Iron	Reduced oxygen transport → retinal hypoxia	Retinal haemorrhages, vessel tortuosity, CRVO risk	Low bioavailability of non-heme iron	Iron supplementation, vitamin C co-intake	[8, 45–48]
Omega-3 (EPA/DHA)	Impaired photoreceptor membrane function, reduced anti-inflammatory activity	Reduced contrast sensitivity, increased AMD risk	Lack of fish-derived fatty acids	Algal supplementation, ALA intake optimisation	[29, 49–53]
Vitamin A	Disrupted visual cycle (rhodopsin), epithelial damage	Night blindness, xerophthalmia, corneal damage	Inefficient conversion from carotenoids	Supplementation, adequate fat intake for absorption	[55–59]

Vitamin A. Vitamin A, as retinal, is essential for the visual cycle, forming rhodopsin in retinal rods for low-light vision and maintaining corneal epithelial integrity [55]. Vitamin A refers to a group of fat-soluble compounds, found in two main forms: provitamin A carotenoids (from plants) and preformed vitamin A (from animal sources). While beta-carotene from plants can be converted into vitamin A in the body, this process is inefficient and depends on the type of food. As a result, even diets rich in fruits and vegetables may not provide enough vitamin A. Preformed vitamin A-such as retinol and its derivatives-is the most biologically active and is commonly used in supplements [6]. Vitamin A deficiency can lead to night blindness and xerophthalmia, particularly in populations with limited access to diverse diets [56]. The World Health Organization (WHO) classifies its stages, which begin with conjunctival dryness-wrinkling and dryness from the loss of goblet cells. Next, Bitot's spots appear – white, foamy patches on the conjunctiva formed by keratin and bacteria. This can progress to corneal xerosis, with symptoms like haze, erosions, and new blood vessel growth, leading to blurry vision. At this stage, high-dose vitamin A can still prevent lasting damage. Without treatment, it may lead to corneal ulcers, keratomalacia, and eventually scarring, where vision can only be restored with a corneal transplant [57]. Studies have suggested that a minimum daily intake of 3–5 g of lipids (e.g. from olive oil) is necessary for the sufficient absorption of β-carotene, which is a critical strategy for vegans [58]. Regular intake of provitamin A-rich foods and fortified products is essential to achieve the recommended 700–900 μg/day retinol activity equivalents. Supplementation with vitamin A palmitate (900 μg/day) may be necessary in high-risk groups to prevent ocular complications [59].

The major nutrient deficiencies associated with plant-based diets, along with their ocular consequences and management strategies, are summarised in Table 2.

DISCUSSION

Vegetarian and vegan diets offer significant benefits for ocular health, particularly through high intake of carotenoids, such as lutein and zeaxanthin, which reduce the risk of AMD and cataracts, thereby supporting visual acuity [3, 10, 11]. The work of Grudzinski et al. underscores that lutein and zeaxanthin, abundant in leafy greens, are critical for protecting the macula from oxidative damage, potentially improving visual acuity and preventing the progression of age-related ocular diseases [3]. Reduced risk of vascular diseases and type 2 diabetes, resulting from low saturated fat intake, further supports ocular health [1, 2].

However, deficiencies in vitamin B12, iron, omega-3 fatty acids, and vitamin A, particularly in vegan diets, can lead to severe complications, such as optic neuropathy, CRVO, or night blindness [6–9]. Pathophysiological mechanisms include tissue hypoxia (iron deficiency), vascular endothelial damage (vitamin B12 deficiency), visual cycle disruption (vitamin A deficiency), and photoreceptor membrane alterations (DHA deficiency) [6, 38, 39, 42]. Research indicates that deficiencies in these nutrients are particularly risky in vegan diets that do not include supplements [7, 41]. Clinical cases, such as those reported by Stambolian et al. and Yang et al., demonstrate that timely intervention can partially reverse damage, but delayed diagnosis may lead to permanent visual impairment [7, 8]. Regular supplementation, particularly with vitamin B12 and algal DHA, is critical for vegans [5, 53, 55]. Iron absorption can be enhanced by combining plant-based foods with vitamin C, which is particularly important for women of reproductive age [40].

Current research has certain limitations, including a lack of long-term prospective data on the impact of plant-based diets on visual acuity, and a scarcity of randomised clinical trials. Most evidence relies on case reports and cross-sectional studies, limiting the generalisability of findings. Future research should focus on monitoring visual parameters, such as visual acuity, macular thickness, or contrast sensitivity, in populations adhering to plant-based diets, and on developing detailed dietary guidelines for vegetarians and vegans.

CONCLUSIONS

Vegetarian and vegan diets can support visual acuity through a high intake of carotenoids, such as lutein and zeaxanthin, and reduce the risk of vascular diseases and type 2 diabetes. However, vitamin B12, iron, omega-3 fatty acids, and vitamin A reduction can cause severe ocular complications, such as optic neuropathy, CRVO, or night blindness, as evident from clinical cases. Regular monitoring of these nutrients, appropriate supplementation and patient education are important to reduce risks. With focus on protecting ocular health, further research is required to develop widespread dietary guidelines for individuals on plant-based diets.

Ethical statement. This review article is based solely on publicly available studies and does not involve any research conducted on human subjects or animals. The author confirms that no financial ties, personal connections, or other conflicts of interest exist that could influence the content or conclusions of the review. Additionally, parts of the text were edited and refined with the assistance of artificial intelligence tools (e.g., Deepl) in accordance with ethical guidelines to enhance clarity and structure without compromising the originality of the content. The author takes full responsibility for the accuracy and integrity of the final manuscript.

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