



International Journal of Innovative Technologies in Social Science

e-ISSN: 2544-9435

Operating Publisher
SciFormat Publishing Inc.
ISNI: 0000 0005 1449 8214

2734 17 Avenue SW,
Calgary, Alberta, T3E0A7,
Canada
+15878858911
editorial-office@sciformat.ca

ARTICLE TITLE

MEDITERRANEAN DIET AND AGE-RELATED MACULAR
DEGENERATION: EVIDENCE FOR A PLANT-FORWARD
NUTRITIONAL STRATEGY IN PREVENTION AND DISEASE
PROGRESSION

DOI

[https://doi.org/10.31435/ijitss.3\(51\).2026.6089](https://doi.org/10.31435/ijitss.3(51).2026.6089)

RECEIVED

19 July 2026

ACCEPTED

10 September 2026

PUBLISHED

18 September 2026

LICENSE



The article is licensed under a **Creative Commons Attribution 4.0 International License**.

© The author(s) 2026.

This article is published as open access under the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

MEDITERRANEAN DIET AND AGE-RELATED MACULAR DEGENERATION: EVIDENCE FOR A PLANT-FORWARD NUTRITIONAL STRATEGY IN PREVENTION AND DISEASE PROGRESSION

Aleksandra Jabłońska (Corresponding Author, Email: aleksandra.jablonska264@gmail.com)
Uniwersytet Jagielloński Collegium Medicum w Krakowie, Kraków, Poland
ORCID ID: 0009-0004-0315-3771

Piotr Wites
Szpital Uniwersytecki w Krakowie, Krakow, Lesser Poland, Poland
ORCID ID: 0000-0001-8234-5560

Hubert Łagosz
5 Wojskowy Szpital Kliniczny z Polikliniką, Kraków, Małopolskie, Poland
ORCID ID: 0009-0008-6635-2400

Patryk Piotrowski
Samodzielny Publiczny Zakład Opieki Zdrowotnej w Myślenicach, Myślenice, Małopolska, Poland
ORCID ID: 0009-0009-3795-3781

Alicja Włodarczyk
Szpital Miejski Specjalistyczny im. G. Narutowicza w Krakowie, Kraków, Poland
ORCID ID: 0009-0009-9711-121X

Katarzyna Wites
Uniwersytet Jagielloński Collegium Medicum w Krakowie, Kraków, Poland
ORCID ID: 0009-0009-1796-0407

Magdalena Pyzik
Szpital św. Anny w Miechowie, Miechów, Poland
ORCID ID: 0009-0000-5771-8935

Kinga Ziółkowska
Śląski Uniwersytet Medyczny w Katowicach, Katowice, Poland
ORCID ID: 0009-0004-1695-4332

Karolina Markusiewicz
Warszawski Uniwersytet Medyczny, Warsaw, Poland
ORCID ID: 0009-0005-0273-386X

Piotr Bahyrycz
Samodzielny Publiczny Zakład Opieki Zdrowotnej w Myślenicach, Myślenice, Małopolska, Poland
ORCID ID: 0009-0009-7369-3366

ABSTRACT

Background: Age-related macular degeneration (AMD) is one of the leading causes of irreversible visual impairment among older adults and represents an increasing public health challenge in aging populations. Although genetic predisposition and advancing age are well-established risk factors, growing evidence suggests that modifiable lifestyle factors, particularly dietary habits, may influence disease development and progression. The Mediterranean diet, characterized by a high intake of fruits, vegetables, legumes, whole grains, nuts, olive oil, and fish, has attracted considerable attention because of its potential protective effects against chronic age-related diseases, including retinal disorders.

Objectives and Methods: The objective of this review was to evaluate current evidence regarding the relationship between Mediterranean dietary adherence and AMD prevention and progression, with particular emphasis on its role as a plant-forward nutritional strategy. Relevant epidemiological studies, prospective cohort studies, secondary analyses of the Age-Related Eye Disease Study (AREDS), population-based investigations, and recent systematic reviews were examined.

Key findings: The available evidence consistently indicates that greater adherence to Mediterranean dietary patterns is associated with a lower risk of AMD progression and, in some populations, reduced disease prevalence. Several biological mechanisms may contribute to these observations, including attenuation of oxidative stress, modulation of inflammatory pathways, improvement of lipid metabolism, and preservation of vascular function. Key nutrients such as lutein, zeaxanthin, omega-3 fatty acids, polyphenols, and antioxidant vitamins appear to play complementary roles within the broader dietary pattern.

Conclusions: Overall, current evidence supports the Mediterranean diet as a promising and practical nutritional approach for promoting retinal health and potentially reducing the burden of AMD. Further prospective intervention studies are needed to clarify causality and optimize dietary recommendations for at-risk populations.

KEYWORDS

Age-Related Macular Degeneration, Mediterranean Diet, Plant-Forward Nutrition, Dietary Patterns, Retinal Health, Disease Progression

CITATION

Jabłońska, A., Wites, P., Łagosz, H., Piotrowski, P., Włodarczyk, A., Wites, K., Pyzik, M., Ziółkowska, K., Markusiewicz, K., & Bahyrycz, P. (2026). Mediterranean diet and age-related macular degeneration: Evidence for a plant-forward nutritional strategy in prevention and disease progression. *International Journal of Innovative Technologies in Social Science*, 3(51). [https://doi.org/10.31435/ijitss.3\(51\).2026.6089](https://doi.org/10.31435/ijitss.3(51).2026.6089)

COPYRIGHT

© The author(s) 2026. This article is published as open access under the Creative Commons Attribution 4.0 International License (CC BY 4.0), allowing the author to retain copyright. The CC BY 4.0 License permits the content to be copied, adapted, displayed, distributed, republished, or reused for any purpose, including adaptation and commercial use, as long as proper attribution is provided.

1. Introduction

1.1. Global Burden of Age-Related Macular Degeneration

Age-related macular degeneration (AMD) is a progressive degenerative disease of the central retina and one of the leading causes of irreversible visual impairment among older adults worldwide. The disorder affects the macula, the retinal region responsible for detailed central vision, and can significantly compromise activities essential for independent living, including reading, driving, and facial recognition. Despite advances in diagnostic techniques and therapeutic interventions, AMD continues to represent a major clinical and public health challenge due to its high prevalence, chronic nature, and strong association with population aging (Wong et al., 2014; Colijn et al., 2017).

The global burden of AMD has increased substantially over recent decades. According to a systematic review and meta-analysis by Wong et al. (2014), the worldwide prevalence of AMD among individuals aged 45–85 years is approximately 8.7%, corresponding to an estimated 196 million affected individuals in 2020. This number is projected to increase to nearly 288 million by 2040 as populations continue to age. Furthermore, AMD is estimated to account for approximately 7–9% of blindness cases worldwide, making it one of the most important causes of irreversible vision loss in industrialized nations (Wong et al., 2014). These projections underscore the urgent need to identify effective preventive strategies capable of reducing disease burden and preserving visual function in aging populations.

1.2. AMD in Europe and Poland

The impact of AMD is particularly evident in Europe, where demographic changes are expected to substantially increase the number of affected individuals in the coming decades. Data from the European Eye Epidemiology Consortium revealed a pronounced age-dependent increase in disease prevalence, with AMD affecting approximately 3.5% of individuals aged 55–59 years and nearly 18% of those aged 85 years and older (Colijn et al., 2017). The prevalence of late AMD, which is associated with the greatest risk of severe visual impairment, increases from approximately 0.1% in younger age groups to nearly 10% among the oldest adults. Moreover, the number of Europeans living with AMD is projected to rise from approximately 34 million individuals in 2013 to nearly 68 million by 2040 (Colijn et al., 2017).

These epidemiological trends are particularly relevant for Poland, where the proportion of older adults continues to increase and age-related chronic diseases are becoming an increasingly important healthcare concern. As life expectancy rises, the prevalence of AMD and its associated socioeconomic consequences are expected to grow correspondingly. While advancing age and genetic susceptibility remain the most established risk factors for AMD, research conducted over the past two decades has increasingly highlighted the importance of modifiable environmental and lifestyle factors. Among these, dietary habits have emerged as a particularly promising area of investigation because they represent a potentially accessible and cost-effective approach to disease prevention and management (Lawrenson & Evans, 2013).

1.3. Geographic Variations in AMD and the Potential Role of Diet

One observation that motivated the development of this review is the apparent geographic variation in AMD burden across Europe. Epidemiological studies have suggested that the prevalence and burden of advanced AMD may be greater in Northern and Central European populations than in populations residing in Southern Europe (Colijn et al., 2017; Hogg et al., 2017). Although these regional differences are likely multifactorial and influenced by genetic, environmental, socioeconomic, and healthcare-related determinants, they have prompted considerable interest in the potential contribution of lifestyle-related factors. From the perspective of a researcher based in Poland, it is particularly intriguing that populations living in Mediterranean regions—where traditional dietary habits remain more prevalent—appear to exhibit more favorable patterns for several age-related chronic diseases. This observation raises the question of whether dietary practices may also contribute to differences in retinal health and AMD risk.

1.4. Mediterranean Diet as a Plant-Forward Nutritional Strategy

Among the dietary patterns that have received increasing scientific attention, the Mediterranean diet has emerged as one of the most extensively studied models of healthy eating. Traditionally characterized by high consumption of fruits, vegetables, legumes, nuts, whole grains, and olive oil, together with moderate fish intake and limited consumption of red and processed meats, the Mediterranean diet provides a diverse range of nutrients and bioactive compounds that may influence mechanisms involved in retinal degeneration (Merle et al., 2015; Nunes et al., 2018). Unlike approaches that focus exclusively on individual nutrients or dietary supplements, the Mediterranean diet represents a holistic dietary pattern in which multiple components may act synergistically to promote health.

Several biological mechanisms support a potential protective role of Mediterranean dietary adherence in AMD. Oxidative stress, chronic inflammation, mitochondrial dysfunction, impaired lipid metabolism, and vascular alterations are recognized contributors to AMD pathogenesis. The Mediterranean diet contains numerous constituents that may modulate these pathways, including antioxidant vitamins, polyphenols, carotenoids, monounsaturated fatty acids, and omega-3 fatty acids. Particular attention has been directed toward lutein and zeaxanthin, which accumulate in the macular pigment and may help protect retinal tissues from oxidative damage, as well as omega-3 fatty acids that contribute to retinal structure and function (Wu et al., 2015; Merle et al., 2014).

Importantly, the Mediterranean diet can also be viewed as a practical example of a plant-forward nutritional strategy. Plant-forward dietary patterns emphasize the consumption of nutrient-dense plant foods while allowing moderate intake of selected animal products, particularly fish. Such an approach naturally provides many nutrients that have been associated with retinal protection, including lutein, zeaxanthin, vitamin C, vitamin E, zinc, and long-chain omega-3 fatty acids.

1.5. Rationale for the Review

Consequently, plant-forward nutrition may represent a sustainable and achievable strategy for reducing AMD risk while simultaneously supporting overall cardiometabolic health. Evidence supporting this hypothesis has expanded considerably in recent years. Analyses from the Age-Related Eye Disease Study (AREDS) demonstrated that greater adherence to a Mediterranean dietary pattern was associated with a lower risk of progression to advanced AMD (Merle et al., 2015). Similar findings have been reported by the Coimbra Eye Study and the European Eye Study, which observed favorable associations between Mediterranean dietary adherence and AMD prevalence or progression (Hogg et al., 2017; Nunes et al., 2018; Raimundo et al., 2018). More recently, systematic reviews and meta-analyses have further strengthened the evidence base, suggesting that Mediterranean-style dietary patterns may contribute to both AMD prevention and disease management (Maresova et al., 2022; Marques-Couto et al., 2025).

Given the increasing prevalence of AMD and the growing recognition of nutrition as a modifiable determinant of health, a comprehensive evaluation of the relationship between Mediterranean dietary patterns and retinal disease is warranted.

1.6. Objectives of the Review

The objective of this review is to critically examine current evidence regarding the association between adherence to the Mediterranean diet and age-related macular degeneration. Specifically, this review aims to (1) discuss the biological mechanisms through which a plant-forward Mediterranean dietary pattern may influence retinal health, (2) summarize epidemiological evidence linking Mediterranean dietary patterns to AMD incidence and progression and (3) evaluate the potential role of Mediterranean-style nutrition as a practical strategy for AMD prevention and disease management. By synthesizing findings from observational studies, prospective cohorts, clinical trials, and recent systematic reviews, this review seeks to provide a comprehensive overview of the current evidence supporting dietary modification as a component of healthy visual aging.

2. Age-Related Macular Degeneration: Pathophysiology and Risk Factors

2.1. Anatomy and Function of the Macula

The macula is a specialized region located in the central retina that is responsible for high-resolution vision, color discrimination, and detailed visual tasks. Within the macula lies the fovea, an area characterized by a high density of cone photoreceptors that enables precise visual acuity. Normal visual function depends on the integrity of multiple interconnected structures, including photoreceptors, retinal pigment epithelial (RPE) cells, Bruch's membrane, and the underlying choroidal vasculature. Together, these components form a highly metabolically active environment that requires a continuous supply of oxygen and nutrients while simultaneously managing substantial oxidative stress generated by exposure to light and high rates of cellular metabolism (Lawrenson & Evans, 2013).

Age-related macular degeneration develops when age-associated structural and functional alterations disrupt the homeostasis of this retinal microenvironment. Progressive damage to retinal tissues can impair central vision and ultimately result in irreversible visual loss in advanced stages of the disease.

2.2. Clinical Classification of Age-Related Macular Degeneration

AMD is a heterogeneous disorder that progresses through several stages. Early AMD is typically characterized by the presence of small to medium-sized drusen and subtle pigmentary abnormalities within the retinal pigment epithelium. At this stage, patients are often asymptomatic or experience only minimal visual disturbances. Intermediate AMD is associated with larger drusen deposits and more pronounced retinal pigment epithelial changes, reflecting increasing disruption of retinal structure and function.

Late AMD is generally classified into two distinct forms: geographic atrophy (dry AMD) and neovascular AMD (wet AMD). Geographic atrophy involves progressive degeneration of retinal pigment epithelial cells, photoreceptors, and the underlying choriocapillaris, leading to irreversible areas of retinal tissue loss. In contrast, neovascular AMD is characterized by the growth of abnormal blood vessels originating from the choroid. These vessels are prone to leakage, hemorrhage, and fibrosis, often resulting in rapid and severe central vision loss if left untreated (Colijn et al., 2017).

Although neovascular AMD accounts for a smaller proportion of total AMD cases, it is responsible for a substantial percentage of severe vision loss associated with the disease. Both forms of late AMD contribute significantly to visual disability and reduced quality of life among older adults.

2.3. Major Risk Factors for AMD

The development of AMD is influenced by a complex interaction between genetic predisposition, aging processes, environmental exposures, and lifestyle factors. Among all known risk factors, increasing age remains the most important determinant of disease risk. The prevalence of AMD rises dramatically in older populations, reflecting the cumulative effects of cellular aging and prolonged exposure to oxidative and inflammatory stressors (Colijn et al., 2017).

Genetic susceptibility also plays a crucial role in AMD pathogenesis. Genome-wide association studies have identified several risk loci associated with disease development, particularly variants within genes involved in complement regulation and inflammatory pathways. Polymorphisms in the complement factor H (CFH) gene and the age-related maculopathy susceptibility 2 (ARMS2) gene are among the most consistently reported genetic risk factors. Recent evidence further suggests that dietary patterns may interact with genetic susceptibility, potentially modifying disease progression among genetically predisposed individuals (Barreto et al., 2023; Merle et al., 2015). Among modifiable risk factors, cigarette smoking is widely recognized as the strongest environmental contributor to AMD development. Smoking promotes oxidative stress, endothelial dysfunction, and chronic inflammation while reducing the availability of circulating antioxidants that are important for retinal protection. Numerous epidemiological studies have consistently demonstrated an increased risk of both early and advanced AMD among current and former smokers.

Cardiovascular and metabolic factors have also been implicated in AMD pathogenesis. Hypertension, dyslipidemia, obesity, and atherosclerotic disease may contribute to impaired retinal perfusion and vascular dysfunction, thereby accelerating degenerative processes within the macula. The observation that AMD shares several risk factors with cardiovascular disease has prompted growing interest in dietary and lifestyle interventions that may simultaneously benefit both conditions (Hogg et al., 2017; Delcourt et al., 2007).

In recent years, dietary habits have emerged as a potentially important modifiable determinant of AMD risk. Studies have demonstrated associations between Western dietary patterns characterized by high consumption of processed foods, saturated fats, and refined carbohydrates and an increased risk of AMD development or progression (Gopinath et al., 2015; Chiu et al., 2014). Conversely, dietary patterns rich in fruits, vegetables, fish, and unsaturated fats appear to be associated with more favorable retinal outcomes (Merle et al., 2015; Nunes et al., 2018).

2.4. Biological Mechanisms Underlying AMD Pathogenesis

Although the precise pathogenesis of AMD remains incompletely understood, current evidence indicates that the disease results from the interaction of multiple biological processes occurring over several decades. These processes include oxidative stress, chronic inflammation, mitochondrial dysfunction, impaired lipid metabolism, and abnormalities of retinal and choroidal circulation.

2.4.1. Oxidative Stress

Oxidative stress is widely regarded as a central mechanism in AMD development. The retina is particularly susceptible to oxidative damage because of its high oxygen consumption, exposure to visible light, and abundance of polyunsaturated fatty acids. Over time, excessive production of reactive oxygen species can damage proteins, lipids, DNA, and cellular organelles within retinal tissues. Age-related reductions in endogenous antioxidant defenses may further increase retinal vulnerability to oxidative injury (Lawrenson & Evans, 2013).

2.4.2. Chronic Inflammation and Complement Activation

Chronic low-grade inflammation is another hallmark of AMD. Accumulating evidence suggests that dysregulation of the complement system contributes to retinal tissue damage and disease progression. Activation of inflammatory pathways promotes cellular injury, recruitment of immune cells, and accumulation of extracellular deposits within the retina. The strong association between AMD and genetic variants affecting complement regulation further supports the importance of inflammatory mechanisms in disease pathogenesis (Barreto et al., 2023).

2.4.3. Drusen Formation and Lipid Dysregulation

One of the earliest clinical signs of AMD is the formation of drusen, extracellular deposits that accumulate between the retinal pigment epithelium and Bruch's membrane. Drusen contain a complex mixture of lipids, proteins, inflammatory mediators, and cellular debris. Their presence reflects impaired clearance mechanisms and alterations in retinal lipid metabolism. Progressive accumulation of drusen can disrupt nutrient transport, promote local inflammation, and contribute to retinal degeneration (Delcourt et al., 2007).

2.4.4. Mitochondrial Dysfunction

Retinal cells possess exceptionally high energy requirements and rely heavily on mitochondrial function to maintain normal physiological activity. Aging-related mitochondrial damage may reduce cellular energy production while increasing oxidative stress, thereby contributing to retinal pigment epithelial dysfunction and photoreceptor loss. Emerging evidence suggests that mitochondrial impairment may represent an important link between aging and AMD development.

2.4.5. Choroidal and Vascular Alterations

Vascular dysfunction also plays a significant role in AMD progression. Age-related changes in the choroidal circulation may impair oxygen and nutrient delivery to retinal tissues, creating a microenvironment that promotes degeneration. In neovascular AMD, ischemic and inflammatory signals stimulate the production of vascular endothelial growth factor (VEGF), leading to pathological angiogenesis and the formation of fragile new blood vessels beneath the retina. These abnormal vessels are prone to leakage and hemorrhage, ultimately causing severe visual impairment if untreated.

2.5. Implications for Nutritional Prevention

The multifactorial nature of AMD suggests that no single nutrient or intervention is likely to fully prevent disease development. Instead, nutritional strategies capable of simultaneously targeting oxidative stress, inflammation, lipid dysregulation, and vascular dysfunction may offer the greatest potential benefit. This concept provides a strong biological rationale for investigating dietary patterns such as the Mediterranean diet, which combines multiple nutrients and bioactive compounds with known antioxidant, anti-inflammatory, and cardioprotective properties. Understanding the mechanisms underlying AMD pathogenesis is therefore essential for evaluating how plant-forward dietary strategies may contribute to retinal health and influence disease progression.

3. Mediterranean Diet and Retinal Health: Characteristics, Mechanisms, and Key Nutrients

3.1. The Mediterranean Diet: Definition and Core Characteristics

The Mediterranean diet is widely recognized as one of the healthiest dietary patterns worldwide and has been extensively investigated for its role in the prevention of chronic diseases. Originally described in populations living in countries bordering the Mediterranean Sea, particularly Greece, Southern Italy, and parts of Spain, this dietary pattern is characterized by a high intake of plant-based foods, including fruits, vegetables, legumes, nuts, seeds, and whole grains. Olive oil serves as the primary source of dietary fat, while fish and seafood are consumed regularly, and red and processed meats are consumed sparingly (Merle et al., 2015; Nunes et al., 2018).

Unlike dietary approaches that focus on individual nutrients, the Mediterranean diet emphasizes overall dietary quality and food synergy. The combination of numerous bioactive compounds derived from plant foods, olive oil, and fish creates a complex nutritional profile that may influence multiple physiological pathways simultaneously. This characteristic has contributed to growing scientific interest in the Mediterranean diet as a model of healthy aging and chronic disease prevention.

A key feature of the Mediterranean dietary pattern is its alignment with the concept of plant-forward nutrition. Plant-forward diets prioritize plant-derived foods as the foundation of daily nutrition while allowing moderate consumption of selected animal products. Such an approach may be particularly relevant for age-related diseases because it provides high levels of antioxidants, dietary fiber, unsaturated fatty acids, vitamins, minerals, and phytochemicals while limiting excessive intake of saturated fats and highly processed foods. Increasing evidence suggests that these dietary characteristics may have important implications for retinal health and the prevention of AMD (Maresova et al., 2022; Marques-Couto et al., 2025).

3.2. Health Benefits of the Mediterranean Diet Beyond Ocular Disease

The health-promoting effects of the Mediterranean diet have been documented across numerous clinical and epidemiological studies. Greater adherence to this dietary pattern has been associated with reduced risk of cardiovascular disease, type 2 diabetes mellitus, hypertension, obesity, cognitive decline, and all-cause mortality. These benefits are believed to result from a combination of anti-inflammatory, antioxidant, metabolic, and vascular effects (Lawrenson & Evans, 2013).

Interestingly, many of the biological pathways implicated in cardiovascular disease overlap with those involved in AMD pathogenesis. Both conditions are characterized by chronic inflammation, oxidative stress, endothelial dysfunction, and abnormalities in lipid metabolism. Consequently, dietary patterns that improve cardiovascular health may also provide benefits for retinal tissues. This shared pathophysiological background has encouraged researchers to investigate whether adherence to the Mediterranean diet may reduce the risk of AMD development and progression (Hogg et al., 2017).

3.3. Biological Mechanisms Linking the Mediterranean Diet to AMD Prevention

3.3.1. Modulation of Oxidative Stress

Oxidative stress is considered one of the central mechanisms contributing to AMD development. Retinal tissues are particularly vulnerable to oxidative injury because of their high oxygen consumption, continuous exposure to light, and abundance of polyunsaturated fatty acids. Over time, excessive production of reactive oxygen species may damage cellular structures, including lipids, proteins, and DNA, ultimately contributing to retinal degeneration.

The Mediterranean diet contains numerous antioxidant compounds capable of counteracting oxidative damage. Fruits, vegetables, nuts, and olive oil provide substantial amounts of vitamin C, vitamin E, carotenoids, flavonoids, and polyphenols, which may help neutralize reactive oxygen species and support endogenous antioxidant defense systems. As a result, adherence to Mediterranean dietary patterns may reduce cumulative oxidative damage within retinal tissues and potentially slow AMD progression (Merle et al., 2014; Wu et al., 2015).

3.3.2. Reduction of Chronic Inflammation

Increasing evidence suggests that chronic low-grade inflammation plays a critical role in AMD pathogenesis. Activation of inflammatory pathways contributes to retinal pigment epithelial dysfunction, drusen formation, and progressive retinal damage. Genetic studies identifying variants in complement-related genes further support the importance of inflammatory processes in disease development (Barreto et al., 2023).

Several components of the Mediterranean diet possess anti-inflammatory properties. Monounsaturated fatty acids from olive oil, omega-3 fatty acids from fish, and numerous plant-derived polyphenols have been shown to influence inflammatory signaling pathways and cytokine production. Through these mechanisms, Mediterranean dietary adherence may contribute to a less pro-inflammatory systemic environment and reduce inflammatory stress within retinal tissues (Merle et al., 2015; Raimundo et al., 2018).

3.3.3. Effects on Lipid Metabolism and Drusen Formation

Disturbances in lipid metabolism have emerged as an important feature of AMD pathophysiology. Drusen, one of the earliest clinical manifestations of AMD, contain substantial quantities of lipids and lipid-related proteins. Accumulation of these deposits may interfere with nutrient transport between the choroid and retina and promote local inflammatory responses.

The Mediterranean diet is characterized by a favorable lipid profile, including high intake of monounsaturated fatty acids from olive oil and omega-3 fatty acids from fish. These dietary fats may improve lipid homeostasis, reduce oxidative modification of lipoproteins, and contribute to maintenance of retinal structural integrity. Such effects may partially explain the observed associations between Mediterranean dietary adherence and reduced AMD progression reported in several observational studies (Merle et al., 2015; Nunes et al., 2018).

3.3.4. Vascular and Endothelial Protection

Adequate blood flow is essential for retinal function because retinal tissues possess exceptionally high metabolic demands. Age-related vascular dysfunction may impair nutrient and oxygen delivery, contributing to retinal degeneration and disease progression.

The Mediterranean diet has consistently been associated with improved endothelial function, reduced blood pressure, and lower cardiovascular risk. Enhanced vascular health may improve choroidal circulation and support retinal metabolism, thereby reducing susceptibility to degenerative changes. These vascular benefits may be particularly relevant in neovascular AMD, where abnormalities in angiogenic signaling contribute to disease progression (Hogg et al., 2017; Delcourt et al., 2007).

3.3.5. Potential Influence on the Gut–Retina Axis

Recent research has suggested that dietary patterns may influence ocular health through interactions between the gut microbiota and systemic immune responses. Plant-rich dietary patterns promote microbial diversity and increase production of beneficial metabolites such as short-chain fatty acids, which may exert anti-inflammatory effects throughout the body. Although evidence regarding the gut–retina axis remains preliminary, this represents an emerging area of interest in AMD research and may provide additional insight into the protective effects of Mediterranean dietary patterns.

3.4. Key Nutrients Relevant to Retinal Health

While the Mediterranean diet functions primarily as a dietary pattern, several individual nutrients contained within this eating model have been identified as particularly important for retinal health.

3.4.1. Lutein and Zeaxanthin

Lutein and zeaxanthin are carotenoids that selectively accumulate within the macular pigment. Their unique location allows them to absorb blue light and reduce oxidative damage generated by photochemical reactions. Higher dietary intake of lutein-rich and zeaxanthin-rich foods, such as leafy green vegetables, has been associated with increased macular pigment density and improved retinal protection (Lawrenson & Evans, 2013; Wu et al., 2015).

3.4.2. Omega-3 Fatty Acids

Docosahexaenoic acid (DHA) is a major structural component of photoreceptor cell membranes and plays a crucial role in retinal function. Together with eicosapentaenoic acid (EPA), omega-3 fatty acids may help regulate inflammatory responses, support membrane stability, and promote retinal integrity. Fish and seafood, which constitute important components of the Mediterranean diet, are among the richest dietary sources of these nutrients (Merle et al., 2014).

3.4.3. Polyphenols

Polyphenols comprise a large group of bioactive plant compounds found in fruits, vegetables, nuts, legumes, and olive oil. Experimental studies suggest that polyphenols may protect retinal tissues through antioxidant, anti-inflammatory, and neuroprotective mechanisms. Although human evidence remains limited, these compounds are increasingly recognized as potential contributors to the beneficial effects of Mediterranean dietary patterns on retinal health.

3.4.4. Antioxidant Vitamins and Trace Minerals

Vitamins C and E, zinc, and copper have attracted considerable attention in AMD research, particularly following findings from the Age-Related Eye Disease Studies (AREDS). These micronutrients contribute to antioxidant defense systems and may help reduce oxidative damage within retinal tissues. Mediterranean dietary patterns naturally provide many of these nutrients through regular consumption of fruits, vegetables, nuts, legumes, and whole grains (Lawrenson & Evans, 2013).

3.5. Dietary Synergy: Beyond Individual Nutrients

Although individual nutrients may contribute to retinal protection, increasing evidence suggests that whole dietary patterns may be more important than isolated nutritional components. Foods are consumed in combination rather than individually, and interactions among nutrients may influence their biological effects. This concept of dietary synergy provides a compelling explanation for why Mediterranean dietary adherence consistently demonstrates stronger associations with retinal health than single-nutrient approaches alone (Merle et al., 2015; Maresova et al., 2022).

Consequently, the Mediterranean diet should be viewed not merely as a source of specific nutrients but as a comprehensive nutritional framework capable of simultaneously targeting multiple mechanisms implicated in AMD pathogenesis. This multifaceted mode of action may explain its potential role in reducing AMD risk and slowing disease progression.

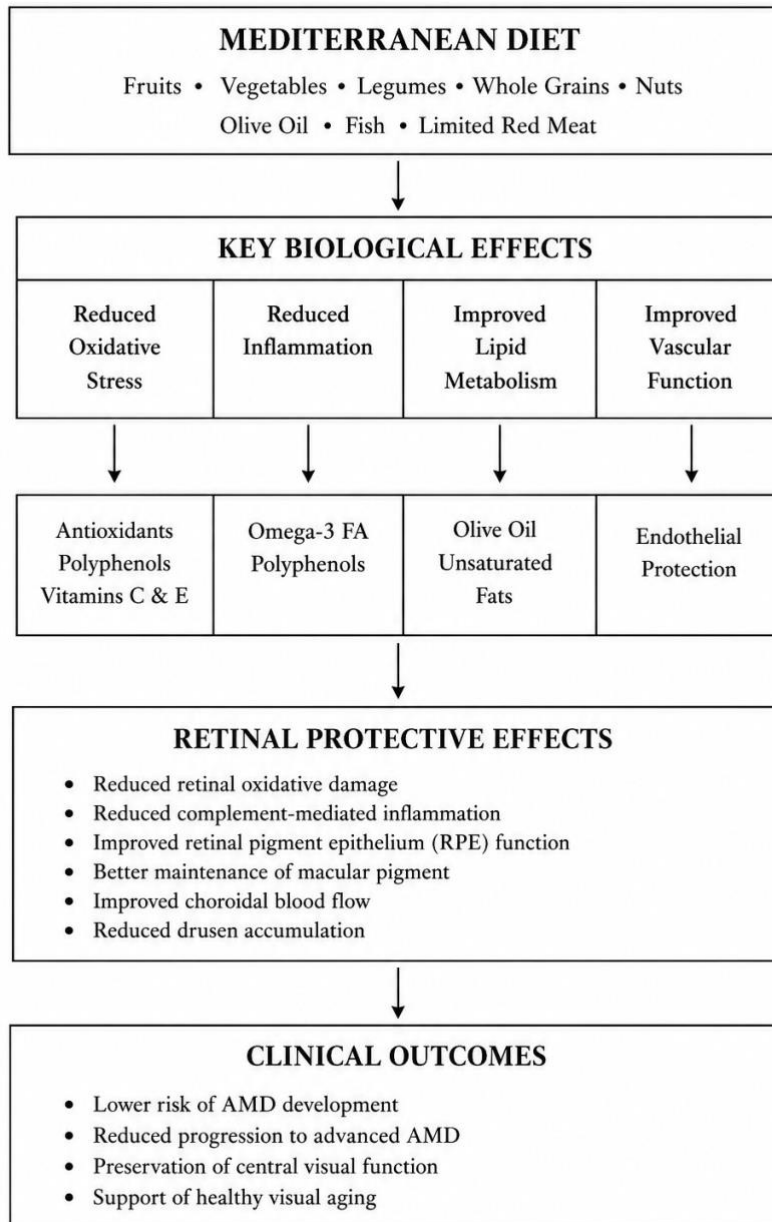


Fig. 1. Proposed biological mechanisms through which adherence to a Mediterranean dietary pattern may influence age-related macular degeneration (AMD). The Mediterranean diet provides a combination of antioxidants, polyphenols, carotenoids, monounsaturated fatty acids, and omega-3 fatty acids that may act through multiple complementary pathways, including reduction of oxidative stress, modulation of inflammation, improvement of lipid metabolism, and enhancement of vascular function. Collectively, these effects may contribute to retinal protection, slower disease progression, and preservation of visual function.

4. Evidence Linking Mediterranean Diet Adherence to AMD Risk and Progression

4.1. Overview of Current Evidence

Interest in the relationship between dietary patterns and AMD has grown substantially over the past two decades. Early nutritional research primarily focused on individual nutrients such as antioxidant vitamins, zinc, lutein, zeaxanthin, and omega-3 fatty acids. However, increasing recognition of the complexity of dietary exposures has shifted attention toward the investigation of whole dietary patterns. Current evidence evaluating the relationship between Mediterranean dietary adherence and AMD consists primarily of observational studies, prospective cohort analyses, and secondary analyses of large clinical datasets. Although randomized controlled trials specifically designed to evaluate Mediterranean dietary interventions in AMD remain limited, findings from multiple independent populations have consistently suggested a protective association between higher Mediterranean diet adherence and reduced risk of AMD progression (Merle et al., 2015; Nunes et al., 2018; Hogg et al., 2017).

4.2. Evidence from the Age-Related Eye Disease Study (AREDS)

The strongest evidence supporting a relationship between Mediterranean dietary adherence and AMD progression originates from analyses of the Age-Related Eye Disease Study (AREDS), one of the most influential longitudinal studies in ophthalmology.

In a landmark analysis, Merle et al. (2015) examined the association between adherence to a Mediterranean dietary pattern and progression to advanced AMD among AREDS participants. Individuals with the highest levels of adherence to the Mediterranean diet demonstrated a significantly lower risk of progression to advanced disease compared with those exhibiting lower adherence. The protective association remained evident after adjustment for numerous confounding variables, including age, smoking status, and total energy intake.

Importantly, the study suggested that the beneficial effects of the Mediterranean diet extended beyond the influence of individual nutrients. Rather than identifying a single dietary component responsible for protection, the findings supported the concept that the overall dietary pattern—including abundant consumption of plant foods, olive oil, and fish—may act synergistically to influence retinal health.

Subsequent analyses further strengthened these observations by demonstrating interactions between dietary habits and genetic susceptibility. Individuals carrying high-risk genetic variants appeared to derive particular benefit from adherence to healthier dietary patterns, suggesting that nutrition may partially modify inherited risk factors associated with AMD development (Barreto et al., 2023).

4.3. Evidence from European Population Studies

4.3.1. The Coimbra Eye Study

Additional support for the protective role of Mediterranean dietary patterns has been provided by the Coimbra Eye Study conducted in Portugal. This population-based investigation evaluated dietary habits using validated Mediterranean diet adherence scores and examined their relationship with AMD prevalence.

Nunes et al. (2018) reported that greater adherence to a Mediterranean dietary pattern was associated with a lower prevalence of AMD. Participants demonstrating stronger adherence consumed higher quantities of fruits, vegetables, legumes, and fish while exhibiting healthier overall lifestyle characteristics. The findings suggested that adherence to a traditional Mediterranean dietary pattern may contribute to retinal protection in community-dwelling older adults.

Raimundo et al. (2018) further explored dietary influences on retinal health within the same population and reported similar associations between healthier dietary patterns and reduced AMD risk. Together, these studies provide important evidence from a Mediterranean population in which traditional dietary practices remain relatively common.

4.3.2. The European Eye Study

The European Eye Study expanded investigation of dietary influences across multiple European populations. Hogg et al. (2017) reported that greater adherence to a Mediterranean-style dietary pattern was associated with lower odds of neovascular AMD. Importantly, this association was observed after adjustment for major confounding variables, suggesting that dietary quality may independently contribute to AMD risk reduction.

These findings are particularly relevant when considered alongside observed geographic differences in AMD prevalence across Europe. Although dietary factors cannot fully explain regional variation, they may represent one component of a broader lifestyle profile influencing retinal health.

4.4. Dietary Pattern Studies Beyond the Mediterranean Diet

Evidence supporting the importance of dietary patterns in AMD is not limited exclusively to studies directly evaluating Mediterranean diet adherence. Several investigations have compared broader dietary patterns and their associations with retinal outcomes.

Chiu et al. (2007) identified distinct dietary patterns among participants and demonstrated that individuals consuming diets characterized by higher intakes of fruits, vegetables, fish, and whole grains generally exhibited lower AMD risk than those consuming diets rich in processed foods and saturated fats. Similar findings were reported in a later study by Chiu et al. (2014), which observed that Western-style dietary patterns were associated with increased risk of progression to advanced AMD.

Collectively, these studies support the hypothesis that dietary quality influences retinal health and that patterns emphasizing plant foods and unsaturated fats may be more beneficial than diets dominated by refined carbohydrates, processed foods, and saturated fats.

4.5. Gene–Diet Interactions in AMD

One of the most rapidly evolving areas of AMD research concerns interactions between nutrition and genetic susceptibility. Although variants within genes such as CFH and ARMS2 significantly influence AMD risk, growing evidence suggests that lifestyle factors may modify the expression of genetic predisposition.

Barreto et al. (2023) reviewed emerging evidence indicating that adherence to healthy dietary patterns, including the Mediterranean diet, may attenuate the impact of certain genetic risk variants. These findings are particularly important because they suggest that individuals with elevated genetic risk may still benefit from lifestyle interventions aimed at reducing disease progression.

The concept of gene–diet interaction aligns with the broader field of precision nutrition, which seeks to develop personalized dietary recommendations based on individual genetic and metabolic characteristics. While further research is required, these observations support the notion that nutrition may play a role even among genetically susceptible individuals.

4.6. Evidence from Systematic Reviews and Meta-Analyses

As the number of observational studies investigating diet and AMD has increased, several systematic reviews and meta-analyses have attempted to synthesize the available evidence.

Maresova et al. (2022) concluded that greater adherence to Mediterranean dietary patterns was generally associated with a reduced risk of AMD development and progression. The authors highlighted the consistency of findings across multiple cohorts and emphasized the potential importance of dietary quality as a modifiable risk factor.

Similarly, Marques-Couto et al. (2025) reviewed recent evidence regarding dietary patterns and retinal health and reported that Mediterranean-style diets consistently demonstrated favorable associations with AMD outcomes. The review emphasized that dietary patterns appeared to exert stronger effects than isolated nutrients, supporting a shift away from reductionist nutritional approaches toward broader dietary recommendations.

Although heterogeneity among studies remains a limitation, systematic reviews have generally reached similar conclusions regarding the potential benefits of Mediterranean dietary adherence for retinal health.

4.7. Critical Appraisal of Current Evidence

Despite encouraging findings, several limitations should be acknowledged when interpreting the available literature. Most studies examining Mediterranean diet adherence and AMD are observational in nature and therefore cannot establish causality. Dietary intake is typically assessed using food frequency questionnaires, which are susceptible to recall bias and measurement error. Additionally, differences in study populations, AMD classification methods, and Mediterranean diet scoring systems may contribute to variability in reported findings.

Nevertheless, the consistency of results across diverse populations and study designs strengthens confidence in the observed associations. Importantly, findings from AREDS analyses, European cohort studies, and systematic reviews converge toward a similar conclusion: individuals demonstrating greater adherence to Mediterranean-style dietary patterns generally exhibit lower risk of AMD progression and, in some studies, lower disease prevalence.

4.8. Summary of Current Evidence

Taken together, current evidence supports a protective association between Mediterranean dietary adherence and AMD outcomes. The strongest support originates from AREDS analyses, which demonstrated reduced progression to advanced AMD among individuals with higher adherence to Mediterranean dietary patterns (Merle et al., 2015). Additional evidence from the Coimbra Eye Study, the European Eye Study, and multiple systematic reviews further reinforces these observations (Hogg et al., 2017; Nunes et al., 2018; Raimundo et al., 2018; Maresova et al., 2022; Marques-Couto et al., 2025).

Although further randomized controlled trials are needed to establish causality, the available evidence suggests that Mediterranean-style plant-forward dietary patterns may represent a promising and practical strategy for supporting retinal health and reducing the risk of AMD progression.

5. Clinical Implications and Public Health Perspectives

5.1. Implications for Clinical Practice

The growing body of evidence linking Mediterranean dietary adherence with reduced risk of AMD progression has important implications for clinical practice. While current therapeutic approaches, particularly anti-vascular endothelial growth factor (anti-VEGF) therapies, have substantially improved outcomes for patients with neovascular AMD, preventive strategies remain essential given the chronic and progressive nature of the disease. Nutritional counseling may therefore represent a valuable component of comprehensive AMD management, particularly for individuals with early or intermediate disease stages.

Healthcare professionals, including ophthalmologists, general practitioners, and dietitians, may consider encouraging dietary patterns characterized by increased consumption of vegetables, fruits, legumes, whole grains, nuts, olive oil, and fish while reducing intake of highly processed foods and saturated fats. Such recommendations are consistent with current evidence supporting both retinal and overall health benefits (Merle et al., 2015; Nunes et al., 2018).

5.2. Public Health Relevance

The potential role of diet in AMD prevention is particularly relevant from a public health perspective. As populations continue to age, the number of individuals affected by AMD is expected to increase substantially, resulting in growing healthcare costs and increased demand for ophthalmic services (Wong et al., 2014; Colijn et al., 2017). Because dietary habits are modifiable, population-level nutritional interventions may offer a cost-effective strategy for reducing disease burden.

Promotion of Mediterranean-style dietary patterns may be especially beneficial in countries experiencing rapid demographic aging, including Poland and other Central European nations. In addition to their potential effects on retinal health, such dietary patterns have well-established benefits for cardiovascular and metabolic health, providing an opportunity to address multiple chronic diseases through a single lifestyle intervention.

5.3. Toward a Preventive Approach to Healthy Visual Aging

Traditionally, AMD management has focused primarily on treatment of advanced disease. However, increasing evidence supports a broader preventive approach that emphasizes modifiable lifestyle factors throughout the aging process. The Mediterranean diet represents a practical example of a plant-forward nutritional strategy that may help target several biological pathways involved in AMD pathogenesis, including oxidative stress, inflammation, lipid dysregulation, and vascular dysfunction.

Although dietary modification cannot eliminate AMD risk entirely, current evidence suggests that greater adherence to healthy dietary patterns may contribute to the preservation of retinal function and support healthy visual aging. Consequently, nutrition should be considered an important component of future strategies aimed at reducing the individual and societal burden of AMD.

6. Limitations of Current Evidence

6.1. Predominance of Observational Studies

One of the most important limitations of the current literature is the predominance of observational study designs. Much of the evidence linking Mediterranean dietary patterns to AMD prevention or slower disease progression originates from cross-sectional studies, prospective cohort studies, and secondary analyses of existing datasets. Although these studies provide valuable insights into potential associations, they cannot establish causal relationships. Individuals who adhere more closely to a Mediterranean diet often engage in other health-promoting behaviors, including regular physical activity, lower smoking rates, and greater healthcare utilization, which may partially contribute to the observed protective effects (Merle et al., 2015; Nunes et al., 2018).

6.2. Challenges in Dietary Assessment

Accurate assessment of dietary intake remains a significant methodological challenge in nutritional epidemiology. Most studies included in this review relied on food frequency questionnaires or self-reported dietary records. These methods are susceptible to recall bias, reporting inaccuracies, and changes in dietary habits over time. Furthermore, differences in the tools used to assess Mediterranean diet adherence may complicate direct comparisons between studies and contribute to variability in reported findings (Maresova et al., 2022).

6.3. Heterogeneity Among Study Populations

Another important limitation relates to differences in study populations and research methodologies. Existing studies have been conducted across diverse geographic regions, age groups, and ethnic backgrounds, often using different AMD classification systems and outcome measures. Variations in genetic susceptibility, lifestyle characteristics, healthcare access, and environmental exposures may influence study results and limit the generalizability of findings to all populations (Hogg et al., 2017; Colijn et al., 2017).

6.4. Limited Evidence from Randomized Controlled Trials

Although observational evidence is relatively consistent, randomized controlled trials specifically designed to evaluate Mediterranean dietary interventions in AMD remain scarce. Consequently, uncertainty persists regarding the magnitude of the protective effect and the extent to which dietary modification alone can influence disease progression. Future intervention studies are needed to clarify causality, determine optimal dietary recommendations, and identify patient groups most likely to benefit from nutritional interventions.

6.5. Complexity of Diet–Disease Relationships

Finally, AMD is a multifactorial disease influenced by aging, genetic factors, smoking, cardiovascular health, and environmental exposures. The Mediterranean diet itself is a complex dietary pattern comprising numerous foods and nutrients that may interact synergistically. As a result, it is often difficult to determine whether observed benefits are attributable to specific dietary components, overall dietary quality, or broader lifestyle patterns. This complexity highlights the need for future research that integrates nutritional, genetic, and clinical data to better understand the mechanisms linking diet and retinal health (Barreto et al., 2023).

Overall, while current evidence supports a potentially protective role of Mediterranean dietary patterns in AMD prevention and progression, these findings should be interpreted within the context of existing methodological limitations. Continued research, particularly well-designed prospective intervention studies, is necessary to strengthen the evidence base and inform future clinical recommendations.

7. Future Research Directions

Although substantial progress has been made in understanding the relationship between dietary patterns and AMD, several important questions remain unanswered. Future research should focus on strengthening the evidence base through well-designed prospective studies and randomized controlled trials specifically evaluating Mediterranean dietary interventions in individuals at different stages of AMD. Such studies would help clarify whether improvements in dietary quality can directly influence disease onset, progression, or visual outcomes.

Another promising area of investigation involves the emerging field of precision nutrition. Advances in genomics have revealed that genetic factors play a major role in AMD susceptibility, particularly through variants affecting complement regulation, lipid metabolism, and inflammatory pathways. Future studies should explore how individual genetic profiles may modify responses to dietary interventions and whether personalized nutritional recommendations could improve prevention strategies for high-risk populations (Barreto et al., 2023).

Further research is also needed to better characterize the biological mechanisms underlying the observed associations between Mediterranean dietary adherence and retinal health. While oxidative stress, inflammation, vascular dysfunction, and lipid dysregulation are recognized contributors to AMD pathogenesis, the relative contribution of individual dietary components and their interactions remains incompletely understood. The integration of advanced biomarkers, metabolomics, and retinal imaging techniques may provide valuable insights into how dietary patterns influence disease development at a molecular and cellular level.

In addition, growing interest in the gut–retina axis presents an exciting opportunity for future investigation. As evidence accumulates regarding the influence of the gut microbiome on systemic inflammation and immune regulation, studies examining interactions between dietary patterns, microbial composition, and retinal health may offer new perspectives on AMD prevention and management.

Finally, future research should consider geographic and cultural differences in dietary habits. Most studies have been conducted in North American and Southern European populations, whereas evidence from Central and Eastern Europe remains relatively limited. Given the projected increase in AMD prevalence in aging European populations, including countries such as Poland, region-specific research may help identify practical and culturally appropriate nutritional strategies for disease prevention.

8. Conclusions

Age-related macular degeneration remains one of the leading causes of irreversible visual impairment among older adults worldwide and represents an increasingly important public health challenge in aging societies. The multifactorial nature of AMD pathogenesis, involving oxidative stress, chronic inflammation, lipid dysregulation, mitochondrial dysfunction, and vascular alterations, highlights the importance of identifying modifiable risk factors that may contribute to disease prevention and management.

The evidence reviewed in this article suggests that adherence to a Mediterranean dietary pattern is associated with favorable retinal health outcomes and may reduce the risk of AMD progression. Findings from the AREDS cohort, the Coimbra Eye Study, the European Eye Study, and recent systematic reviews consistently indicate that individuals who consume diets rich in fruits, vegetables, legumes, whole grains, olive oil, and fish tend to demonstrate more favorable AMD-related outcomes than those following less healthy dietary patterns (Merle et al., 2015; Hogg et al., 2017; Nunes et al., 2018; Maresova et al., 2022).

The Mediterranean diet may exert these beneficial effects through multiple complementary mechanisms, including reduction of oxidative stress, modulation of inflammatory pathways, improvement of lipid metabolism, and support of vascular function. Importantly, these effects are likely attributable to the combined influence of the overall dietary pattern rather than any single nutrient in isolation. This observation supports the growing shift within nutritional science from nutrient-centered approaches toward the evaluation of whole dietary patterns and their synergistic effects on health.

Although current evidence remains largely observational and additional intervention studies are needed to establish causality, the consistency of findings across diverse populations provides a strong rationale for considering Mediterranean-style plant-forward nutrition as part of a comprehensive strategy for healthy visual aging. Given its established benefits for cardiovascular, metabolic, and overall health, promotion of Mediterranean dietary principles may offer a practical, accessible, and sustainable approach to reducing the burden of AMD in aging populations.

In conclusion, the Mediterranean diet represents a promising nutritional strategy for AMD prevention and disease management. As the global prevalence of AMD continues to rise, integrating evidence-based dietary recommendations into clinical practice and public health initiatives may contribute to the preservation of visual function and improvement of quality of life among older adults.

Acknowledgments: No conflicts of interest to declare.

Author Contributions: Conceptualization: A.J. methodology, K.W., P.W. Literature search: H.L., K.Z. and A.W. Formal Analysis: P.P., M.P. and P.W. Validation: P.B, A.W. Writing—original draft preparation: K.W, M.P. and A.J. Writing—Review and editing: K.Z., P.P. Supervision, P.B.

REFERENCES

1. Merle, B. M. J., Silver, R. E., Rosner, B., & Seddon, J. M. (2015). Adherence to a Mediterranean diet, genetic susceptibility, and progression to advanced macular degeneration: A prospective cohort study. *The American Journal of Clinical Nutrition*, 102(5), 1196–1206. <https://doi.org/10.3945/ajcn.115.111047>
2. Nunes, S., Alves, D., Barreto, P., Raimundo, M., Cachulo, M. L., Farinha, C., Láins, I., Rodrigues, J., Almeida, C., Ribeiro, L., Figueira, J., Santos, L., & Silva, R. (2018). Adherence to a Mediterranean diet and its association with age-related macular degeneration: The Coimbra Eye Study—Report 4. *Nutrition*, 51–52, 6–12. <https://doi.org/10.1016/j.nut.2017.12.010>
3. Raimundo, M., Mira, F., Cachulo, M. L., Barreto, P., Ribeiro, L., Farinha, C., Láins, I., Nunes, S., Alves, D., Figueira, J., Merle, B. M. J., Delcourt, C., Santos, L., & Silva, R. (2018). Adherence to a Mediterranean diet, lifestyle and age-related macular degeneration: The Coimbra Eye Study—Report 3. *Acta Ophthalmologica*, 96(8), e926–e932. <https://doi.org/10.1111/aos.13772>
4. Barreto, P., Farinha, C., Coimbra, R., Láins, I., Rodrigues, J., Nunes, S., Alves, D., Figueira, J., Santos, L., & Silva, R. (2023). Interaction between genetics and adherence to the Mediterranean diet: The risk for age-related macular degeneration. Coimbra Eye Study Report 8. *Eye and Vision*, 10(1), 38. <https://doi.org/10.1186/s40662-023-00355-0>
5. Hogg, R. E., Woodside, J. V., McGrath, A., Young, I. S., Vioque, J., Chakravarthy, U., de Jong, P. T. V. M., Rahu, M., Seland, J., Soubrane, G., Tomazzoli, L., Topouzis, F., & Fletcher, A. E. (2017). Mediterranean diet score and its association with age-related macular degeneration: The European Eye Study. *Ophthalmology*, 124(1), 82–89. <https://doi.org/10.1016/j.ophtha.2016.09.019>
6. Marques-Couto, P., Coelho-Costa, I., Ferreira-da-Silva, R., & Andrade, J. P. (2025). Mediterranean diet on development and progression of age-related macular degeneration: Systematic review and meta-analysis of observational studies. *Nutrients*, 17(6), 1037. <https://doi.org/10.3390/nu17061037>
7. OpenAI. (2025). *ChatGPT* (June 2025 version) [Large language model]. <https://chatgpt.com/>
8. Gastaldello, A., Giampieri, F., Quiles, J. L., Navarro-Hortal, M. D., Aparicio, S., García Villena, E., Tutusaus Pifarre, K., De Giuseppe, R., Grosso, G., Cianciosi, D., Forbes-Hernández, T. Y., Nabavi, S. M., & Battino, M. (2022). Adherence to the Mediterranean-style eating pattern and macular degeneration: A systematic review of observational studies. *Nutrients*, 14(10), 2028. <https://doi.org/10.3390/nu14102028>
9. Lawrenson, J. G., & Evans, J. R. (2013). Nutrition and age-related macular degeneration. *Eye*, 27(6), 664–672
10. Chapman, N. A., Jacobs, R. J., & Braakhuis, A. J. (2019). Role of diet and food intake in age-related macular degeneration: A systematic review. *Clinical and Experimental Ophthalmology*, 47(1), 106–127. <https://doi.org/10.1111/ceo.13343>
11. Colijn, J. M., Buitendijk, G. H. S., Prokofyeva, E., Alves, D., Cachulo, M. L., Khawaja, A. P., Cougnard-Grégoire, A., Merle, B. M. J., Korb, C., Erke, M. G., Bron, A., Anastasopoulos, E., Meester-Smoor, M. A., Segato, T., Piermarocchi, S., de Jong, P. T. V. M., Vingerling, J. R., Topouzis, F., Delcourt, C., ... Klaver, C. C. W. (2017). Prevalence of age-related macular degeneration in Europe: The past and the future. *Ophthalmology*, 124(12), 1753–1763. <https://doi.org/10.1016/j.ophtha.2017.05.035>
12. Age-Related Eye Disease Study Research Group. (2001). A randomized, placebo-controlled clinical trial of high-dose supplementation with vitamins C and E, beta carotene, and zinc for age-related macular degeneration and vision loss. *Archives of Ophthalmology*, 119(10), 1417–1436. <https://doi.org/10.1001/archopht.119.10.1417>
13. Age-Related Eye Disease Study 2 Research Group. (2013). Lutein + zeaxanthin and omega-3 fatty acids for age-related macular degeneration: The Age-Related Eye Disease Study 2 (AREDS2) randomized clinical trial. *JAMA*, 309(19), 2005–2015. <https://doi.org/10.1001/jama.2013.4997>
14. Seddon, J. M., Rosner, B., Sperduto, R. D., Yannuzzi, L., Haller, J. A., Blair, N. P., & Willett, W. (2001). Dietary fat and risk for advanced age-related macular degeneration. *Archives of Ophthalmology*, 119(8), 1191–1199. <https://doi.org/10.1001/archopht.119.8.1191>

15. Seddon, J. M., George, S., & Rosner, B. (2006). Cigarette smoking, fish consumption, omega-3 fatty acid intake, and associations with age-related macular degeneration: The US Twin Study of Age-Related Macular Degeneration. *Archives of Ophthalmology*, 124(7), 995–1001. <https://doi.org/10.1001/archophth.124.7.995>
16. Chiu, C. J., Milton, R. C., Gensler, G., & Taylor, A. (2007). Dietary carbohydrate and the progression of age-related macular degeneration: A prospective study from the Age-Related Eye Disease Study. *The American Journal of Clinical Nutrition*, 86(4), 1210–1218. <https://doi.org/10.1093/ajcn/86.4.1210>
17. Chiu, C. J., Chang, M. L., Zhang, F. F., Li, T., Gensler, G., & Taylor, A. (2014). The relationship of major American dietary patterns to age-related macular degeneration. *American Journal of Ophthalmology*, 158(1), 118–127.e1. <https://doi.org/10.1016/j.ajo.2014.04.016>
18. Wu, J., Cho, E., Willett, W. C., Sastry, S. M., & Schaumberg, D. A. (2015). Intakes of lutein, zeaxanthin, and other carotenoids and age-related macular degeneration during two decades of prospective follow-up. *JAMA Ophthalmology*, 133(12), 1415–1424. <https://doi.org/10.1001/jamaophthalmol.2015.3590>
19. Wong, W. L., Su, X., Li, X., Cheung, C. M. G., Klein, R., Cheng, C. Y., & Wong, T. Y. (2014). Global prevalence of age-related macular degeneration and disease burden projection for 2020 and 2040: A systematic review and meta-analysis. *The Lancet Global Health*, 2(2), e106–e116. [https://doi.org/10.1016/S2214-109X\(13\)70145-1](https://doi.org/10.1016/S2214-109X(13)70145-1)
20. Merle, B. M. J., Benlian, P., Puche, N., Bassols, A., Delcourt, C., & Souied, E. H. (2014). Circulating omega-3 fatty acids and neovascular age-related macular degeneration. *Investigative Ophthalmology & Visual Science*, 55(3), 2010–2019. <https://doi.org/10.1167/iovs.14-13916>
21. Delcourt, C., Carrière, I., Cristol, J. P., Lacroux, A., Gerber, M., & POLA Study Group. (2007). Dietary fat and the risk of age-related maculopathy: The POLANUT Study. *European Journal of Clinical Nutrition*, 61(11), 1341–1344. <https://doi.org/10.1038/sj.ejcn.1602685>
22. Evans, J. R., & Lawrenson, J. G. (2017). Antioxidant vitamin and mineral supplements for preventing age-related macular degeneration. *Cochrane Database of Systematic Reviews*, 7, CD000253. <https://doi.org/10.1002/14651858.CD000253.pub4>
23. Gopinath, B., Flood, V. M., Louie, J. C. Y., Burlutsky, G., Rochtchina, E., Mitchell, P., & Wang, J. J. (2015). Consumption of a Western diet and the risk of age-related macular degeneration. *American Journal of Ophthalmology*, 159(1), 186–191.e1. <https://doi.org/10.1016/j.ajo.2014.09.026>