

PHYTOCHEMICAL-RICH DIETS IN HEALTHY AGEING (MINI-REVIEW)**Parchami Ghazaei Sepideh***Candidate of biological sciences, Associate professor, Associate professor of the Department of Pharmacology and Pharmacotherapy, Kyiv Medical University, Kyiv, Ukraine,***Kozymenko T.***MD, Associate professor, Associate professor of the Department of Pharmacology and Pharmacotherapy, Kyiv Medical University***Zakrutko L.***MD, PhD, Associate professor, Head of the Department of Science Postgraduate and Doctoral Studies, Kyiv Medical University***Novykova L.***MPharm, Senior lecturer, Senior lecturer of the Department of Pharmacology and Pharmacotherapy, Kyiv Medical University, Kyiv, Ukraine,***Marchenko-Tolsta K.***MD, Senior lecturer, Senior lecturer of the Department of Pharmacology and Pharmacotherapy, Kyiv Medical University, Kyiv, Ukraine,***Fedorytenko R.***MPharm, Assistant of the Department of Pharmacology and Pharmacotherapy, Kyiv Medical University*<https://doi.org/10.5281/zenodo.16875591>**Abstract**

Emerging evidence supports the potential of dietary strategies in modulating the biological processes of ageing. Among these, the Mediterranean diet—characterised by high consumption of nuts, extra virgin olive oil, fruits, vegetables, whole grains, and other phytochemical-rich foods—has gained recognition for its protective effects against age-related cellular and molecular damage. This dietary pattern, rich in bioactive compounds such as phenolic compounds, tocochromanols, and triterpenes, is associated with reduced oxidative stress, inflammation, and genomic instability—key contributors to the ageing process. Evidence suggest, that greater adherence to healthful plant-based diet indices was linked to significantly lower phenotypic age acceleration (PhenoAgeAccel) and biological age acceleration (BioAgeAccel), indicating slower ageing. The flavonol content of nuts may contribute to a reduced risk of type 2 diabetes and obesity. Moreover, the presence of monounsaturated and polyunsaturated fatty acids in nuts has been shown to regulate cholesterol levels and inhibit pancreatic lipase activity, thereby supporting cardiovascular health. Flavonoid-, carotenoid-, and anthocyanin-rich blends demonstrate protective effects on DNA integrity, antioxidant capacity, retinal function, and gene expression pathways related to repair and signalling. By influencing critical pathways involved in cardiometabolic regulation, neuroprotection, cancer prevention, and psychological well-being, the Mediterranean diet offers a holistic approach to promoting healthy ageing.

Keywords: Phytochemical-rich foods, Mediterranean diet, Healthy ageing

Introduction: Recent perspectives in biomedical research emphasise a shift from traditional disease-specific approaches towards strategies that target the fundamental biological processes of ageing. Prioritising these biological processes over isolated disease-specific treatments offers a preventive strategy with the potential to enhance healthspan and reduce the burden of multiple age-related conditions. By focusing on mechanisms—such as cellular senescence, metabolic dysfunction, and chronic inflammation—this approach may delay the onset of several chronic disorders simultaneously, thereby overcoming the limitations of conventional paradigms. As highlighted by Demaria, such a geroscience-driven framework represents a broader and more sustainable pathway to improving health in ageing populations [1].

Discussion: Among modifiable factors, promoting a healthy lifestyle—including appropriate dietary patterns—emerges as a key determinant of healthy ageing and helps reduce the risk of non-communicable diseases [2]. Rich in fish, unsaturated fats, whole grains, fruits, vegetables, nuts, and legumes, the Mediterranean

diet is a key source of essential nutrients and phytochemicals [3] known to exert antimicrobial, antiviral, anticancer, anti-inflammatory, antioxidant, neuroprotective, and anti-aging effects [4]. It is well recognised that oxidative stress and inflammation play major roles in mediating ageing [5]. This highlights the relevance of bioactive compounds such as phenolic compounds, tocochromanols, and triterpenes in nuts, given their potential to modulate these processes. phytochemical contents of nuts has been analysed by Wojdyło et al. [6]. For instance, among the nuts analysed, walnuts exhibited the highest total polyphenol (432.9 mg/100 g) and flavonoid content (415.1 ± 2.7 mg/100 g). In contrast, the greatest concentrations of α -tocopherol (vitamin E) were observed in hazelnuts and almonds, at 2551.0 and 2489.7 μ g/100 g, respectively. Notably, pine nuts contain the highest total triterpene content (690.3 mg/100 g), with oleanolic acid comprising nearly 50% of this amount. Moreover, strong positive correlations have been observed between the antioxidant activities of the different phenolic forms (free, esterified, and bound) in walnut kernels and their respective concentrations [7].

Evidence indicates that dietary patterns significantly influence the incidence and prevention of chronic diseases [8]. In this context, a cross-sectional analysis of 22,363 US adults from the National Health and Nutrition Examination Survey examined the association between plant-based diet quality and biological markers of ageing. The study found that greater adherence to healthful plant-based diet indices was linked to significantly lower phenotypic age acceleration (PhenoAgeAccel) and biological age acceleration (BioAgeAccel), indicating slower ageing. Conversely, higher adherence to unhealthful plant-based diets was associated with accelerated ageing [9]. Consistently with these findings, Shang et al., in their large cohort analysis of participants aged 30–75 years, investigated the Alternate Mediterranean Diet (aMED) score, Alternate Healthy Eating Index-2010, and Healthful Plant-based Diet Index scores, and observed that healthy dietary patterns were associated with a reduced risk of cardiometabolic disorders [10]. The Mediterranean diet has been shown to mitigate obesity-related risks and reduce the incidence of chronic conditions, including heart failure [11], as well as type 2 diabetes mellitus [12]. *In vitro* analyses of nut extracts revealed that pecan exhibited strong inhibitory activity against pancreatic α -amylase (>60% inhibition, $IC_{50} = 148.9 \mu\text{g/mL}$), pancreatic lipase (69%), and intestinal α -glucosidase (99% inhibition, $IC_{50} = 13.9 \mu\text{g/mL}$ at 1 mg/mL), suggesting potential for reducing the risk of type 2 diabetes and obesity. Additionally, the inhibition of pancreatic α -amylase may be partially attributed to its flavonol content. Moreover, the presence of monounsaturated and polyunsaturated fatty acids in nuts has been shown to regulate cholesterol levels and inhibit pancreatic lipase activity, thereby supporting cardiovascular health [6]. Likewise, extra virgin olive oil, a key component of the Mediterranean diet, is rich in polyphenolic compounds and monounsaturated fatty acids, which exert anti-inflammatory and antioxidant effects and are associated with a reduced risk of atherosclerosis [13, 14]. Results of a randomized crossover trial demonstrated that flavonoid- and carotenoid-rich blends reduced DNA damage, while anthocyanin- and carotenoid-rich blends enhanced antioxidant capacity. Furthermore, flavonoid–anthocyanin combinations improved retinal function, and gene expression analyses revealed changes in pathways related to DNA repair and cellular signalling, providing mechanistic insights [15]. These findings underscore the potential role of phytochemical-rich diets in mitigating age-related molecular damage and supporting healthy ageing.

Several systematic reviews and meta-analyses have demonstrated an inverse association between adherence to the Mediterranean diet and the risk of certain cancers, as well as cancer-related mortality [10, 15, 16]. In particular, a systematic review and meta-analysis by Giordano et al. found that following this dietary pattern may reduce cancer incidence in older adults, although no significant effect on mortality was observed [17]. Evidence suggests that Mediterranean diet may help prevent neurodegenerative conditions such as dementia and Alzheimer's [10, 18]. Given that nuts are an essential element of this diet, their inhibitory activity against

acetylcholinesterase and butyrylcholinesterase may support preventive strategies for Alzheimer's and Parkinson's diseases [6]. Moreover, extra virgin olive oil exerts neuroprotective effects through the prevention of oxidative neuronal damage, which is associated with a reduced risk of cognitive disorders [13, 14]. Interestingly, antioxidant-rich plant foods have been shown to exert beneficial effects on cognition—whether acute, preventive, or therapeutic—not only through their antioxidant properties but also via additional mechanisms, in healthy individuals, those with mild cognitive impairment, and those with dementia [19].

Depression in older adults warrants specific attention due to its distinct risk factors—such as physical illness, cognitive decline, functional impairment, and lifestyle-related determinants—which are more prevalent in later life. Despite its significant impact on morbidity, quality of life, and both suicidal and non-suicidal mortality, it remains frequently underdiagnosed in primary care settings [20]. In support of lifestyle-related influences, evidence from a large-scale prospective cohort study indicated that greater adherence to the aMED score was associated with a lower risk of incident depression, particularly among individuals aged 65 and older. Compared with those demonstrating low adherence, individuals with moderate adherence had a 13% lower risk ($HR = 0.87$, 95% $CI = 0.76–0.99$), while those with high adherence exhibited a 17% reduction ($HR = 0.83$, 95% $CI = 0.70–0.98$) [21]. These findings highlight the potential of dietary interventions, particularly the Mediterranean diet, as a non-pharmacological strategy for promoting mental health in older adults.

Future perspectives

The growing body of evidence linking phytochemical-rich diets to healthy ageing underscores the need for multidisciplinary research that bridges nutritional science, molecular biology, and public health. Future investigations should prioritise long-term, large-scale prospective studies and randomised controlled trials to clarify causal relationships between specific phytochemical profiles and clinical outcomes in ageing populations. Advances in metabolomics, transcriptomics, and other omics-based technologies will allow for more precise mapping of phytochemical–host interactions, including the identification of novel biomarkers that reflect early improvements in biological ageing processes. Integrating these data into predictive models may guide targeted dietary interventions aimed at optimising healthspan. Finally, future research should not only assess disease prevention but also evaluate the capacity of phytochemical-rich diets to support resilience against stressors, preserve functional independence, and improve quality of life in older adults. Such a holistic perspective will be crucial for moving from generalised dietary advice towards precision nutrition strategies tailored to the ageing individual.

Conclusion

Targeting the biological processes of ageing through dietary strategies has gained increasing scientific support. The Mediterranean diet, rich in nuts, extra virgin olive oil, and other phytochemical-dense foods, presents a promising means of mitigating oxidative

stress, inflammation, and molecular damage associated with ageing. By modulating key pathways involved in cardiometabolic health, neuroprotection, cancer prevention, and mental well-being, this dietary pattern provides a comprehensive framework for supporting healthy ageing. Incorporating such evidence-based nutritional approaches into public health initiatives may offer a sustainable way to extend healthspan and reduce the burden of age-related diseases.

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