The Role of Natural Medicines in Inhibiting Aging

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Abstract. Aging and aging-related diseases constitute a global public health concern. As such, the development of efficient anti-aging agents has emerged as a vital research field in the life sciences. In recent years, a growing body of evidence has demonstrated that natural medicines possess distinct advantages—including abundant bioactive components, low toxicity and side effects, and multi-target regulatory properties—that enable them to influence aging and aging-related diseases. Specifically, they can modulate key physiological processes of the organism, such as lipid metabolism, glucose metabolism, oxidative stress, and cellular autophagy, thereby exhibiting significant potential in the anti-aging domain. This paper reviews the latest research progress on the therapeutic effects of active components derived from natural medicines against aging and aging-related diseases, including neurodegenerative diseases, cardiovascular diseases, diabetes, and cancer. Furthermore, it systematically summarizes the potential mechanisms underlying the anti-aging actions of natural medicines. The findings presented herein aim to provide a comprehensive reference for subsequent studies focused on aging and aging-related diseases, and to facilitate the development of novel, safe, and effective anti-aging strategies based on natural resources.

Keywords: Natural Medicines, Anti-aging, Natural Plant Activice Components, Aging-related Diseases.

1. Introduction

Population aging has become a major global concern. It is estimated that by 2030, the population aged 60 years and over will account for 20% of the world's total population, and the incidence of all age-related diseases will increase exponentially [1]. China has entered an aging society, making it urgent to address the labor shortage caused by population aging. Aging is a physiological phenomenon characterized by the gradual decline in human physiological functions with increasing age, which leads to the occurrence of various health problems and diseases [2]. With the intensification of global population aging, delaying aging and improving the quality of life of the elderly have become significant challenges facing modern society. The search for methods and drugs to delay aging has long been a hot research direction in the field of life sciences. Among these efforts, research on natural plants plays a crucial role in exploring clinical approaches to delay the aging process in China [3].

Modern aging theories suggest that the mechanism of aging involves multiple factors, such as lipid metabolism, glucose metabolism, oxidative stress, and decreased cellular autophagy capacity [4-7]. Although synthetic drugs (e.g., rapamycin, metformin [8, 9]) have achieved certain progress in anti-aging research, controversies remain regarding their long-term safety and side effects. In contrast, natural plants exhibit broad application prospects in aging delay, owing to their abundant bioactive components, low toxicity and side effects, and multi-target regulatory properties. Many of these components have been proven to possess anti-aging effects.

2. Application of Natural Plants in Delaying Aging

2.1. Polyphenolic Compounds

Polyphenolic compounds are a large class of secondary metabolites widely present in plants. They have become the core of anti-aging research due to their strong antioxidant and anti-inflammatory properties. Their mechanism of action extends beyond simple free radical scavenging, involving the

regulation of complex cellular signaling pathways. Resveratrol is an outstanding representative of this class; by activating SIRT1 deacetylase, it mimics the effect of caloric restriction, thereby regulating energy metabolism, enhancing stress resistance, and extending healthy lifespan [10]. Curcumin can mediate subcellular signaling pathways such as AMPK, AKT/mTOR, and NF-κB, effectively inhibiting diseases closely associated with aging [11]. The multiple benefits of polyphenols make them ideal candidates for intervening in age-related diseases, including neurodegenerative diseases and cardiovascular diseases.

2.2. Flavaonoid Compounds

Flavonoid compounds are an important subclass of polyphenols, abundant in fruits, vegetables, and tea, and exert anti-aging effects through multiple pathways. Quercetin, a flavonoid widely found in apples, onions, broccoli, and berries, is recognized as one of the most effective natural antioxidants, capable of efficiently scavenging free radicals such as superoxide anions and peroxides [12]. Beyond direct antioxidant activity, quercetin activates autophagy by upregulating the expression of autophagy-related proteins, thereby resisting H_2O_2-induced aging and damage [13]. Anthocyanins, with their potent free radical scavenging ability, demonstrate excellent performance in improving vascular endothelial function and enhancing cognitive ability [14], highlighting the multi-system protective effects of flavonoid compounds.

2.3. Terpenoid Compounds

Terpenoid compounds are composed of isoprene units, with diverse types, and exhibit unique value in anti-aging applications. Ginsenosides, the main active components of ginseng, belong to triterpenoid saponins and possess extensive pharmacological activities in anti-aging. Studies have shown that ginsenosides can improve mitochondrial function and protect telomeres from shortening by regulating multiple signaling pathways, thereby delaying cellular aging [15]. Andrographolide, a diterpenoid compound, exhibits significant anti-inflammatory and anti-oxidative stress properties, which can significantly alleviate aging and related diseases and show potential in extending healthy lifespan [16], reflecting the structural diversity and functional versatility of terpenoid compounds.

2.4. Alkaloid Compounds

Alkaloids are a class of nitrogen-containing basic organic compounds, many of which have significant pharmacological activities. Berberine is a widely studied anti-aging alkaloid; similar to metformin, it can effectively activate the AMPK pathway, improve glucose and lipid metabolism disorders, thereby delaying metabolic aging and preventing age-related diseases such as type 2 diabetes [17]. Trigonelline can enhance the antioxidant, heat-resistant, and anti-pathogen stress capabilities of Caenorhabditis elegans, and delay the development of neurodegenerative diseases in the Caenorhabditis elegans model [18], making it one of the most promising anti-aging agents.

2.5. Polysaccharide Compounds

Polysaccharides are polymers formed by the condensation of multiple monosaccharide molecules, and their anti-aging mechanism is closely related to immune regulation. Ganoderma lucidum (Lingzhi Mushroom) and Lycium barbarum (Goji Berry) are traditional tonic foods. Modern studies have shown that Ganoderma lucidum polysaccharides and Lycium barbarum polysaccharides possess significant immune-enhancing functions. They can reverse or slow down age-related immune decline, and enhance the body’s ability to monitor and eliminate infections and carcinogenesis by activating dendritic cells, macrophages, and T lymphocytes [19,20]. Additionally, some polysaccharides may indirectly contribute to their anti-aging effects through antioxidant activity and maintaining telomere stability [21].

2.6. Plant-Derived Vitamin Compounds

Vitamins are essential trace organic compounds for sustaining life, and many plant-derived vitamins are key antioxidants. Vitamin C (ascorbic acid) is the most important water-soluble antioxidant in the human body; it directly neutralizes free radicals and acts as a cofactor in collagen biosynthesis, which is crucial for maintaining skin elasticity and vascular health [22]. Vitamin E, on the other hand, is the main fat-soluble antioxidant, localized in cell membranes, and can effectively prevent lipid peroxidation and protect the integrity of membrane structures [23]. These two vitamins work synergistically to form a defense line in the body's antioxidant defense system, slowing down the aging process driven by oxidative stress.

2.7. Fatty Acid Compounds

Plant-derived polyunsaturated fatty acids, particularly α-linolenic acid, are important components of the phospholipid bilayer of cell membranes. By maintaining the fluidity and stability of cell membranes, they ensure the normal function of membrane receptors and signal transduction [24]. Furthermore, ω-3 fatty acids are precursors of anti-inflammatory mediators in the body, helping to counteract the chronic low-grade inflammatory state associated with aging. They are particularly important for maintaining the health of the brain (rich in lipids) and the cardiovascular system, and serve as key dietary components for delaying the aging of the neurodegenerative and cardiovascular systems [25].

3. Conclusion

Natural plants hold distinct advantages in anti-aging research, which are rooted in their inherent biological characteristics. They are enriched with a diverse array of bioactive components, such as polyphenols (e.g., resveratrol, curcumin), flavonoids (e.g., quercetin, anthocyanins), terpenoids, alkaloids, and polysaccharides—constituents that are pivotal for exerting anti-aging effects. Compared with synthetic anti-aging agents (e.g., rapamycin, metformin) whose long-term safety and side effects remain controversial, natural plants exhibit favorable safety profiles, characterized by low toxicity and minimal adverse effects. Moreover, they display multi-target regulatory properties, which align with the complex, multi-pathway nature of aging, enabling simultaneous modulation of interconnected aging-related processes.

Numerous active components isolated from natural plants can enhance the body's resilience against external stressors (including oxidative damage, inflammatory insults, and metabolic disturbances) via dual mechanisms: regulating anti-inflammatory pathways (e.g., inhibiting the NF-κB signaling cascade) and strengthening antioxidant defenses (e.g., scavenging reactive oxygen species and upregulating endogenous antioxidant enzymes like superoxide dismutase). These actions collectively mitigate age-associated physiological decline and retard senescence progression. Concurrently, natural plants have shown therapeutic potential in ameliorating age-related pathologies, encompassing cardiovascular disorders (e.g., atherosclerosis), neurological diseases (e.g., Alzheimer's disease), and type 2 diabetes.

Nevertheless, current research on natural plants in anti-aging therapy faces notable limitations. Most studies are confined to in vitro models (e.g., cultured fibroblasts), while in vivo animal experiments (using models like Caenorhabditis elegans or mice) are relatively scarce, undermining the translational validity of in vitro findings. Thus, rigorous in vivo evaluations and well-designed clinical trials (involving pharmacokinetic analysis and long-term safety monitoring) are imperative to verify reliability. Additionally, despite their proven anti-aging efficacy, gaps persist in understanding the bioavailability of natural plant components (often compromised by poor solubility) and their potential drug-drug interactions. In conclusion, natural plants represent a valuable resource, and addressing these limitations will be critical for advancing novel anti-aging drug development.

References

[1] Costantino S, Paneni F, Cosentino F. Ageing, metabolism and cardiovascular disease. J Physiol. 2016 Apr 15; 594 (8): 2061 - 73.

[2] Schumacher B, Pothof J, Vijg J, et al. The central role of DNA damage in the ageing process. Nature. 2021; 592 (7856): 695 - 703.

[3] Wei X C, Li X R, He J G, et al. Research Progress on Mechanisms of Anti-Aging Effects of Active Components in Traditional Chinese Medicine [J]. Chinese Traditional Patent Medicine, 2025, 47 (04): 1220 - 1227.

[4] Chen W, He H L, Zheng Y J, et al. Research Progress on Caenorhabditis elegans in the Evaluation of Food Nutritional Functions [J]. Food and Machinery, 2024, 40 (01): 197 - 203.

[5] Liu T J, Zhao Y J, Hu J L, et al. Effect of Abnormal Glucose Metabolism on Serum Activin A Level[J]. Practical Geriatrics, 2024, 38 (05): 495 - 499.

[6] Hajam YA, Rani R, Ganie SY, et al. Oxidative Stress in Human Pathology and Aging: Molecular Mechanisms and Perspectives. Cells. 2022 Feb 5; 11 (3): 552.

[7] Kaushik S, Tasset I, Arias E, et al. Autophagy and the hallmarks of aging. Ageing Res Rev. 2021 Dec; 72: 101468.

[8] Selvarani R, Mohammed S, Richardson A. Effect of rapamycin on aging and age-related diseases-past and future. Geroscience. 2021 Jun; 43 (3): 1135 - 1158.

[9] Kulkarni AS, Gubbi S, Barzilai N. Benefits of Metformin in Attenuating the Hallmarks of Aging. Cell Metab. 2020 Jul 7; 32 (1): 15 - 30.

[10] Rogina B, Tissenbaum HA. SIRT1, resveratrol and aging. Front Genet. 2024 May 9; 15: 1393181.

[11] He Y, Liu Y, Zhang M. The beneficial effects of curcumin on aging and age-related diseases: from oxidative stress to antioxidant mechanisms, brain health and apoptosis. Front Aging Neurosci. 2025 Jan 20; 17: 1533963.

[12] Cruz-Gregorio A, Aranda-Rivera AK. Quercetin and Ferroptosis. Life (Basel). 2023 Aug 11; 13 (8): 1730.

[13] Cai M, Li Q, Cao Y, etal. Quercetin activates autophagy to protect rats' ovarian granulosa cells from H2O2-induced aging and injury. Eur J Pharmacol. 2024 Mar 5; 966: 176339.

[14] Auger C, Muzammel H, Diouf I, et al. Potential of Anthocyanin-rich Products to Prevent and Improve Endothelial Function and Senescence: Focus on Anthocyanins. J Agric Food Chem. 2024 Dec 18; 72 (50): 27590 - 27618.

[15] Hou J, Yun Y, Jeon B, et al. Ginsenoside F1-Mediated Telomere Preservation Delays Cellular Senescence. Int J Mol Sci. 2023 Sep 19; 24 (18): 14241.

[16] Cai Y, Huang L, Hou Y, et al. Molecular mechanisms of andrographolide-induced kidney injury and senescence via SIRT3 inhibition. Toxicol Appl Pharmacol. 2025 May; 498: 117306.

[17] Shrivastava S, Sharma A, Saxena N, et al. Addressing the preventive and therapeutic perspective of berberine against diabetes. Heliyon. 2023 Nov 3; 9 (11): e21233.

[18] Zeng WY, Tan L, Han C, et al. Trigonelline Extends the Lifespan of C. Elegans and Delays the Progression of Age-Related Diseases by Activating AMPK, DAF-16, and HSF-1. Oxid Med Cell Longev. 2021 Sep 25; 2021: 7656834.

[19] Cör D, Knez Ž, Knez Hrnčič M. Antitumour, Antimicrobial, Antioxidant and Ant acetylcholinesterase Effect of Ganoderma Lucidum Terpenoids and Polysaccharides: A Review. Molecules. 2018 Mar 13; 23 (3): 649.

[20] Tian X, Liang T, Liu Y, et al. Extraction, Structural Characterization, and Biological Functions of Lycium Barbarum Polysaccharides: A Review. Biomolecules. 2019 Aug 21; 9 (9): 389.

[21] Zhang XP, Liu J, Xu CY, et al. Effect of Angelica sinensis polysaccharide on expression of telomere, telomerase and P53 in mice aging hematopoietic stem cells. Zhongguo Zhong Yao Za Zhi. 2013 Jul; 38 (14): 2354 - 8.

[22] Jaros A, Zasada M, Budzisz E, et al. Evaluation of selected skin parameters following the application of 5% vitamin C concentrate. J Cosmet Dermatol. 2019 Feb; 18 (1): 236 - 241.

[23] Domazetovic V, Falsetti I, Viglianisi C, et al. Protective Role of Natural and Semi-Synthetic Tocopherols on TNFα-Induced ROS Production and ICAM-1 and Cl-2 Expression in HT29 Intestinal Epithelial Cells. Antioxidants (Basel). 2021 Jan 22; 10 (2): 160.

[24] Mariniello K, Min Y, Ghebremeskel K. Phosphorylation of protein kinase B, the key enzyme in insulin-signaling cascade, is enhanced in linoleic and arachidonic acid-treated HT29 and HepG2 cells. Nutrition. 2019 Jan; 57: 52 - 58.

[25] Guichardant M, Véricel E, Lagarde M. Biological relevance of double lipoxygenase products of polyunsaturated fatty acids, especially within blood vessels and brain. Biochimie. 2019 Apr; 159: 55 - 58.