Seabuckthorn in neurodegenerative disorders

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Abstract

Seabuckthorn (Hippophae rhamnoides) is a medicinal plant rich in nutrients recognized for its abundant vitamins, minerals, fatty acids, and bioactive flavonoids, positioning it as a valuable option in neuroprotection research. This review examines the therapeutic capabilities of seabuckthorn concerning neurodegenerative diseases, including Alzheimer's disease, Parkinson's disease, Huntington's disease, and amyotrophic lateral sclerosis (ALS), all characterized by intricate mechanisms such as oxidative stress, neuroinflammation, mitochondrial dysfunction, and neuronal death. Special emphasis is placed on the flavonoid components of seabuckthorn—such as isorhamnetin, quercetin, and kaempferol—which exhibit considerable antioxidant, anti-inflammatory, and neuroprotective properties. These compounds have been demonstrated to influence vital signaling pathways, including PI3K/Akt and ERK, relevant to cell survival, synaptic plasticity, and neuronal differentiation. By addressing various pathological mechanisms, seabuckthorn flavonoids provide a multifaceted strategy for reducing neuronal damage and encouraging regeneration. This review underscores current experimental and preclinical research that supports the application of seabuckthorn as a dietary supplement and complementary therapy for neurodegenerative disorders. Additional clinical research is required to confirm these effects and to determine standardized dosages and formulations

Introduction

Seabuckthorn, scientifically referred to as Hippophae rhamnoides, is a deciduous shrub indigenous to the cold-temperate areas of Europe and Asia, which has been utilized for centuries in traditional healing practices and as a dietary supplement. This resilient plant is celebrated for its vividly orange berries, which are extremely abundant in bioactive compounds and nutrients. The berries boast significant amounts of vitamins—most notably vitamin C, vitamin E, and various B

vitamins—as well as carotenoids like beta-carotene, contributing to their robust antioxidant properties. Moreover, seabuckthorn berries offer a range of minerals such as potassium, calcium, magnesium, and iron, making them a vital source of essential nutrients for supporting overall wellness. The oil derived from the seeds and pulp is also loaded with omega fatty acids, including omega-3, -6, -7, and -9, which are essential for heart health, immune function, and skin care. These nutritional characteristics render seabuckthorn an excellent addition to a healthy diet, aiding in cellular defense, diminishing oxidative stress, and promoting metabolic activities.

In addition to its fundamental nutritional benefits, seabuckthorn is especially esteemed for its rich content of flavonoids—an extensive group of phytonutrients recognized for their powerful antioxidant, anti-inflammatory, and anti-cancer properties. The main flavonoids present in seabuckthorn include isorhamnetin, quercetin, kaempferol, and their glycosides. These compounds collaborate effectively to neutralize free radicals, alleviate inflammation, and influence cellular signaling pathways. For instance, isorhamnetin has been researched for its capability to modulate significant intracellular pathways linked to cell survival and apoptosis, while quercetin is widely acknowledged for its broad spectrum of biological activities, including neuroprotection and immune response regulation. Kaempferol, another key flavonoid found in seabuckthorn, has been associated with enhanced cardiovascular health and anti-inflammatory effects, in addition to potential advantages in preventing chronic diseases. The presence of these flavonoids not only boosts the health-promoting effects of seabuckthorn but also indicates a potential role for its consumption in preventing and managing various disorders, particularly those impacting the nervous system

Neurodegenerative disorders are a group of conditions marked by the gradual deterioration of neuronal structure and function, resulting in cognitive decline, motor dysfunction, and often significant disability. Well-known neurodegenerative diseases include Alzheimer’s disease, Parkinson’s disease, Huntington’s disease, and amyotrophic lateral sclerosis (ALS). These disorders typically involve intricate pathological mechanisms such as the buildup of misfolded proteins, oxidative stress, mitochondrial dysfunction, neuroinflammation, and excitotoxicity. In Alzheimer’s disease, for instance, the accumulation of beta-amyloid plaques and tau tangles impairs neuronal communication and triggers inflammatory reactions, ultimately leading to

extensive neuronal death. In the case of Parkinson's disease, the loss of dopamine-producing neurons in the substantia nigra results in motor difficulties and various non-motor symptoms, including cognitive and mood-related issues. Despite considerable research efforts, effective treatments that can halt or reverse the advancement of neurodegenerative disorders remain difficult to find, underscoring the necessity for innovative therapeutic strategies that address multiple pathological processes at once.

The complex mechanisms underlying neurodegenerative disorders involve a series of interconnected events. Oxidative stress, caused by an imbalance between the creation of free radicals and the body's capacity to neutralize them, is a critical factor in neuronal damage. Neurons are especially susceptible to oxidative harm due to their high metabolic activity and relatively low levels of natural antioxidants. This oxidative stress can lead to lipid peroxidation, DNA damage, and protein oxidation, which further worsen neuronal dysfunction. Simultaneously, chronic neuroinflammation—characterized by microglial activation and the release of pro-inflammatory cytokines—creates a harmful environment that accelerates neuronal loss. Furthermore, mitochondrial dysfunction disrupts energy generation and encourages apoptotic pathways, contributing further to cell death. These overlapping mechanisms not only jeopardize neuronal survival but also hinder synaptic plasticity and neurogenesis, both of which are vital for cognitive function and the brain's ability to repair itself. The combined impact of these pathological processes results in the gradual clinical deterioration seen in neurodegenerative diseases.

Neurodegenerative diseases, although they exhibit some shared pathological characteristics, differ significantly in their clinical presentation and the specific molecular abnormalities that underlie them. In the case of Alzheimer's disease, the build-up of beta-amyloid plaques and neurofibrillary tangles disrupts synaptic function and leads to extensive neuronal loss, particularly in areas of the brain responsible for memory and cognitive functions. Conversely, Parkinson's disease is marked by the targeted degeneration of dopaminergic neurons in the substantia nigra, which causes motor symptoms such as tremors, stiffness, and slowed movements, alongside non-motor symptoms like cognitive decline and mood issues. Huntington's disease is defined by a genetic mutation that produces a harmful protein, resulting in the gradual deterioration of neurons in the basal ganglia and cerebral cortex. In contrast, amyotrophic lateral sclerosis (ALS) primarily impacts motor

neurons, resulting in muscle weakness and paralysis. Despite these distinctions, the collective involvement of oxidative stress, mitochondrial dysfunction, neuroinflammation, and disrupted cellular signaling highlights the potential for common therapeutic approaches. Flavonoids derived from seabuckthorn, by addressing these shared mechanisms, present a promising opportunity for developing treatments that could be effective across various neurodegenerative conditions.

The convergence of traditional herbal remedies and contemporary scientific inquiry has opened new avenues for addressing complex diseases. Seabuckthorn, known for its diverse range of nutrients and bioactive compounds, is a prime example of this convergence. The potent flavonoids contained within not only deliver strong antioxidant and anti-inflammatory properties but also have the ability to modulate essential intracellular signaling pathways that control cell survival, differentiation, and programmed cell death. By stimulating pathways such as PI3K/Akt and ERK, these flavonoids can foster neuronal survival and regeneration, counteracting harmful processes associated with neurodegeneration. Additionally, their capacity to target multiple pathways at once addresses the multifaceted nature of neurodegenerative diseases, making them particularly appealing for therapeutic development.

Conclusion

Seabuckthorn (Hippophae rhamnoides), recognized for its exceptional nutritional and medicinal attributes, has gained attention as a potentially effective natural agent in the prevention and treatment of neurodegenerative diseases. Its abundant supply of vital nutrients—including vitamins (particularly vitamin C and E), minerals, omega fatty acids, and a wide range of flavonoids—uniquely qualifies it as both a functional food and a therapeutic substance. Among the diverse bioactive materials found in seabuckthorn, flavonoids like isorhamnetin, quercetin, and kaempferol stand out due to their various biological effects, notably their neuroprotective capabilities.

Neurodegenerative conditions, such as Alzheimer’s disease, Parkinson’s disease, Huntington’s disease, and amyotrophic lateral sclerosis (ALS), are marked by the gradual degeneration of neurons, which results in significant cognitive, motor, and functional deficits. These disorders share common underlying mechanisms, including oxidative stress, chronic neuroinflammation, mitochondrial dysfunction, the buildup of harmful protein aggregates, and disrupted neuronal signaling. Existing therapeutic interventions mostly address symptoms and do not stop or reverse

the progression of these diseases, highlighting the critical need for novel approaches that target the fundamental causes of neurodegeneration.

In this light, the neuroprotective capacity of seabuckthorn flavonoids becomes particularly significant. These compounds demonstrate potent antioxidant properties, capable of neutralizing reactive oxygen species and diminishing oxidative harm to neuronal cell membranes, proteins, and DNA.

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