



Modulation of Oxidative Stress in Neurodegenerative Diseases by Polyphenols

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Description

The nervous system, encompassing the brain, spinal cord, and nerves, is the control center of the body. It is responsible for everything from basic bodily functions to complex cognitive processes. However, this intricate system is highly susceptible to damage from oxidative stress, a process that involves the overproduction of Reactive Oxygen Species (ROS) or free radicals. Over time, oxidative stress can lead to neurodegenerative diseases such as Alzheimer's disease, Parkinson's disease, and multiple sclerosis.

Oxidative stress in the nervous system

Oxidative stress occurs when there is an imbalance between free radicals and antioxidants in the body. Free radicals are unstable molecules that can damage cells, proteins, and DNA. The brain is particularly vulnerable to oxidative stress due to its high oxygen consumption, abundance of lipids, and relatively low antioxidant defenses.

Neurons, the primary cells of the nervous system, are especially prone to oxidative damage because of their high metabolic activity and limited capacity for regeneration. When oxidative stress overwhelms the nervous system, it can lead to neuroinflammation, neuronal death, and the accumulation of damaged proteins, all of which contribute to the progression of neurodegenerative diseases.

Antioxidants are compounds that neutralize free radicals, thereby reducing oxidative stress. By protecting lipids, proteins, and DNA from oxidative damage, antioxidants help maintain cellular integrity and function. Polyphenols are a diverse group of bioactive compounds found abundantly in plant-based foods. These compounds have garnered significant attention for their neuroprotective properties.

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Polyphenols and their neuroprotective mechanisms

Polyphenols exert their beneficial effects on the nervous system through multiple mechanisms.

Scavenging free radicals: Polyphenols can directly neutralize free radicals, reducing oxidative damage to neurons. For example, flavonoids, a subclass of polyphenols found in berries, tea, and cocoa, have been shown to decrease oxidative stress in the brain.

Reducing neuroinflammation: Chronic inflammation in the nervous system is a hallmark of neurodegenerative diseases. Polyphenols have anti-inflammatory properties that can help mitigate this inflammation. For instance, resveratrol, a polyphenol found in red wine and grapes, has been shown to inhibit the production of pro-inflammatory molecules in the brain.

Modulating cellular signaling pathways: Polyphenols can influence cellular signaling pathways that regulate antioxidant defenses. For example, the activation of the Nrf2 pathway, a key regulator of antioxidant response, can be stimulated by polyphenols like curcumin (found in turmeric) and quercetin (found in apples and onions). This activation enhances the production of endogenous antioxidants, further protecting neurons from oxidative damage.

Inhibiting protein aggregation: In neurodegenerative diseases, misfolded proteins often accumulate and form toxic aggregates. Polyphenols can interfere with this aggregation process, reducing the formation of harmful protein clumps. For example, green tea polyphenols have been shown to inhibit the aggregation of amyloid-beta proteins, which are implicated in Alzheimer's disease.

Promoting neurogenesis: Some polyphenols have been found to promote the growth and survival of neurons, a process known as neurogenesis. This is particularly

important for repairing damage in the nervous system. For example, studies have shown that the polyphenol Epigallocatechin Gallate (EGCG), found in green tea, can enhance neurogenesis in the hippocampus, a brain region critical for memory.

Dietary sources of polyphenols

Incorporating polyphenol-rich foods into the diet is a natural way to support nervous system health. Some of the best dietary sources of polyphenols include:

Berries: Blueberries, strawberries, and blackberries are rich in flavonoids and anthocyanins, which have strong antioxidant and anti-inflammatory properties.

Tea and coffee: Green tea, black tea, and coffee are abundant in polyphenols like catechins and chlorogenic acid, which have been shown to protect against neurodegeneration.

Dark chocolate: Cocoa, the main ingredient in dark chocolate, contains flavonoids that have been linked to

improved cognitive function and reduced oxidative stress.

Red wine and grapes: Resveratrol, found in red wine and grapes, has been extensively studied for its neuroprotective effects.

Turmeric: Curcumin, the active compound in turmeric, has potent antioxidant and anti-inflammatory properties that can protect the nervous system.

Antioxidants, particularly polyphenols, offer a protecting strategy for protecting the nervous system from oxidative stress and neurodegenerative diseases. By scavenging free radicals, reducing inflammation, modulating signaling pathways, inhibiting protein aggregation, and promoting neurogenesis, polyphenols play a multifaceted role in maintaining nervous system health. Incorporating a diet rich in antioxidant-containing foods, along with supporting the body's natural antioxidant defenses, can be a powerful strategy for promoting long-term brain health and protecting against neurological disorders.