Science Review: Sulforaphane

Sulforaphane is a type of isothiocyanate and a metabolite of glucoraphanin—a phytonutrient found in cruciferous vegetables, such as broccoli, Brussels sprouts, and cabbage.[1] Studies show that high consumption of cruciferous vegetables is associated with reduced risk of total and cardiovascular disease mortality.[2]

Research Highlights

- ✓ Sulforaphane is a well-studied isothiocyanate due to its antioxidant, anti-inflammatory, and detoxification properties[3]
- ✓ Sulforaphane modulates the nuclear factor-kappa B (NFkB) pathway, a central regulator of DNA transcription and pro-inflammatory cytokine production[4]
- ✓ Sulforaphane is produced only when the enzyme myrosinase comes into contact with glucoraphanin[5]
- ✓ Increased levels of cellular stress are a common characteristic of numerous conditions, such as cardiovascular disease, cancer, and Alzheimer's. Sulforaphane has been shown to help mediate the protective protein Nrf2, which serves as a main regulator of the body's protective antioxidant responses against cellular stress[6]

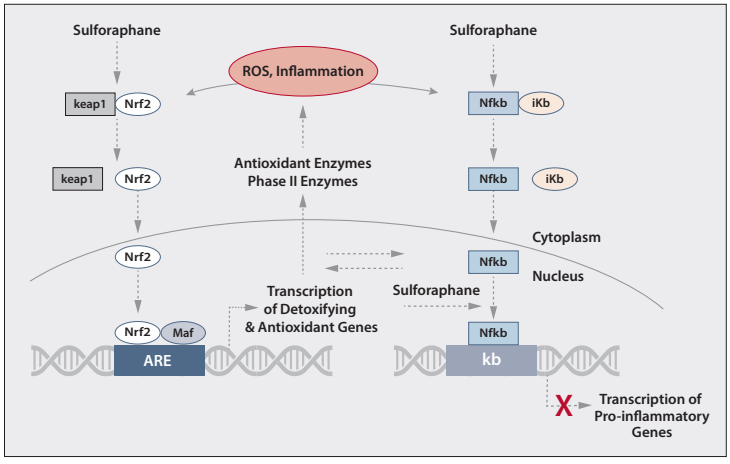
Mechanism of Action

Sulforaphane appears to be a potent activator of the cellular antioxidant pathway Keep1/Nrf2/ARE and other anti-inflammatory mechanisms, including inhibition of the Nfkb pathway (Figure 1).[3,4]

Sulforaphane works to protect cells against harmful agents by helping to turn on antioxidant genes—thus allowing the body to produce antioxidant enzymes.

These enzymes produce anti-inflammatory and detoxification activities that help protect against chronic conditions (Figure 1).

Figure 1



Carcinogenesis

Dietary chemopreventive isothiocyanates, including sulforaphane, have well established anti-cancer properties.[7] Sulforaphane is a monofunctional inducer since it selectively increases Phase II detoxification enzyme activities without affecting Phase I biotransformation enzymes (cytochrome P450).[7] Along with antioxidant enzymes (glutathione S-transferases), Phase II detoxification protects cells from carcinogens and reactive oxygen species (ROS) via the Nrf2 pathway.[6]

Neurodegenerative Conditions

Several in-vitro and in-vivo studies have demonstrated sulforaphane's potential to act as a neuroprotective agent in models of neurodegenerative disorders, such as Alzheimer's and Parkinson's disease. This protective mechanism is likely due to sulforaphane's ability to activate the Nrf2/ARE pathway.[8]

Detoxification

Phases I and II of detoxification are necessary for the elimination of harmful substances, such as carcinogens, aflatoxins, food additives, and environmental pollutants. Phase II enzymes are induced by the Nrf2 pathway, which prevents the accumulation of harmful metabolites and allows for inactivation or rapid excretion before they cause damage to critical cellular molecules.[1] Not only is sulforaphane a very potent inducer of Phase II enzymes, it also raises cellular glutathione levels via the Nrf2/ARE pathway.[6,10]

Inflammation

Sulforaphane has also been shown to reduce inflammation—a key underlying mechanism in many chronic diseases, such as cardiovascular disease, Crohn's, diabetes, and COPD. Key factors in sulforaphane's anti-inflammatory properties include its capability to bind to the toll-like receptor-4 (TLR4) in addition to blocking the activation of its downstream transcription factor, known as NFkB, which is responsible for controlling and signaling the expression of several pro-inflammatory cytokines (LPS, TNF-α, CRP, IL-6, etc.) in response to inflammatory signals.[9]

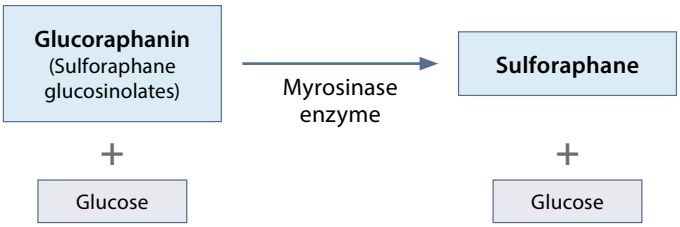
H. pylori

Helicobacter pylori (H. pylori) is a bacterium strongly associated with inflammation of the stomach lining, ulcers, and increased risk of stomach cancer. *H. pylori* infections express high urease activity, which generates ammonia, neutralizes gastric acidity, and promotes inflammation. Studies conclude the bactericidal activity of sulforaphane leads to the inactivation of *H. pylori* urease, which may reduce inflammation.[11]

Myrosinase Enzyme

Myrosinase enzyme is necessary for the conversion of glucoraphanin to sulforaphane. This enzyme is activated when the cruciferous plant tissue is crushed, chewed, or chopped but is inactivated when subjected to sustained boiling or heat, thus reducing the conversion of glucosinolates.[12] Although myrosinase may also be produced by bacteria in the gut to create sulforaphane from raw glucoraphanin, the conversion capabilities vary and depend on the health of an individual's gut microbiome.[12]

Figure 2



Conclusion

Activation of the myrosinase enzyme is required to convert glucoraphanin to sulforaphane—an isothiocyanate with health-promoting properties. After conversion, sulforaphane can yield various health benefits, such as cellular health protection, Phase II detoxification support, neuroprotection, and reduction of inflammation.

References:
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