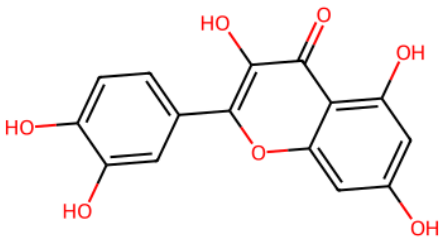
Quercetin

Main functional characteristics: Antioxidant, anti-inflammatory, cardioprotective, metabolic regulator

Molecular weight: 302.24 g/mol



Scientific description

Quercetin is a flavonol belonging to the polyphenol family, widely distributed in fruits, vegetables, tea, and wine. Its structure contains multiple hydroxyl groups and a catechol ring, which provide strong radical scavenging activity and metal-chelating properties, making it one of the most potent dietary antioxidants.

Beyond its direct antioxidant capacity, quercetin enhances endogenous defense systems by activating the Nrf2/ARE pathway. This activation induces the transcription of antioxidant enzymes such as SOD, CAT, GPx, and HO-1, thus protecting cells against chronic oxidative stress and reducing the risk of damage associated with atherosclerosis, diabetes, and neurodegeneration.

Quercetin also plays a significant role as an anti-inflammatory compound. It suppresses NF-κB activation, thereby reducing the expression of pro-inflammatory mediators such as TNF-α, IL-1β, IL-6, iNOS, and COX-2. Additionally, it modulates MAPK signaling cascades (ERK, JNK, p38), further contributing to the inhibition of adhesion molecules (ICAM-1, VCAM-1) and controlling vascular inflammation.

From a cardiovascular perspective, quercetin prevents the oxidation of low-density lipoprotein (LDL), enhances endothelial function by increasing nitric oxide (NO) bioavailability, and lowers blood pressure in hypertensive patients. Clinical studies have confirmed a reduction in both systolic and diastolic blood pressure after quercetin supplementation.

Regarding glucose and lipid metabolism, quercetin activates AMPK in liver and skeletal muscle, promoting glucose uptake via GLUT4 and enhancing fatty acid oxidation. These effects improve insulin sensitivity and prevent hepatic lipid accumulation. Quercetin also modulates PPARγ expression, contributing to lipid homeostasis.

The bioavailability of quercetin is relatively low due to intestinal and hepatic first-pass metabolism, leading to conjugated forms such as glucuronides, sulfates, and methylated derivatives. However, the intestinal microbiota plays an essential role in liberating the aglycone form and generating active metabolites that contribute to systemic bioactivity.

Clinically, quercetin has been investigated as an adjuvant in metabolic, cardiovascular, and neurodegenerative diseases. Its combined antioxidant and anti-inflammatory effects make it a promising candidate for the prevention of metabolic syndrome, type 2 diabetes, obesity, and dyslipidemias, as well as for neuroprotection in Alzheimer's and Parkinson's diseases.

In conclusion, quercetin is a multifunctional flavonoid that impacts multiple physiological systems. Its ability to modulate key pathways such as Nrf2, NF-κB, and AMPK positions it as a strategic molecule for the development of standardized botanical extracts with nutraceutical, pharmaceutical, and functional food applications.

References

1. 1. Li Y, et al. Quercetin, inflammation and immunity. Nutrients. 2016;8(3):167. doi:10.3390/nu8030167.
2. 2. Boots AW, et al. Health effects of quercetin: from antioxidant to nutraceutical. Eur J Pharmacol. 2008;585(2-3):325-337. doi:10.1016/j.ejphar.2008.03.008.
3. 3. Egert S, et al. Quercetin reduces BP and oxidised LDL in overweight subjects. Br J Nutr. 2009;102(7):1065-1074. doi:10.1017/S0007114509359124.
4. 4. Pérez-Vizcaíno F, Duarte J. Flavonols and cardiovascular disease. Mol Aspects Med. 2010;31(6):478-494. doi:10.1016/j.mam.2010.09.002.
5. 5. Zhang W, et al. Research progress of quercetin in cardiovascular disease. Nutrients. 2023;15(22):4875. doi:10.3390/nu15224875.
6. 6. Xiao J, Högger P. Dietary polyphenols and type 2 diabetes. Curr Med Chem. 2015;22(1):23-38. doi:10.2174/0929867321666140916111551.
7. 7. Guo Y, Bruno RS. Endogenous and exogenous mediators of quercetin bioavailability. J Nutr Biochem. 2015;26(3):201-210. doi:10.1016/j.jnutbio.2014.10.008.
8. 8. Russo M, et al. Quercetin and its metabolites in health and disease. Phytother Res. 2014;28(10):1581-1592. doi:10.1002/ptr.5184.
9. 9. Yang D, et al. Quercetin: its main pharmacological activity and potential application. Oxid Med Cell Longev. 2020;2020:8825387. doi:10.1155/2020/8825387.
10. 10. Li Y, et al. Quercetin improves endothelial function: meta-analysis. Medicine (Baltimore). 2016;95(24):e3382. doi:10.1097/MD.0000000000003382.