

Despite the beneficial effect of curcumin on longevity and health, curcumin also has an issue of low bioavailability. The problems and promises of the bioavailability of curcumin are well described in a review by Anand *et al.*¹³¹ The low bioavailability of curcumin is contributed by curcumin's poor absorption from the intestine, rapid metabolism, and rapid systemic elimination. For example, a 650 mg capsule of curcuminoids was not detected in the serum for 6 h in healthy volunteers, and oral administration of 12 g of curcumin yielded only nanogram concentrations in serum in other human trials.^{131–133} To solve this problem, numerous methods have been tried. For example, curcumin analogues and highly stabilized curcumin nanoparticles have been developed, and their effects have been investigated.^{134,135} Despite its low bioavailability, curcumin is safe in animals and humans, even at high doses.^{136–138}

13.3.2 Quercetin

Quercetin (3,3',4',5,7-pentahydroxyflavon) is a flavonoid found in herbal edibles like onions, apples, and broccolis, as well as in red wine, tea, and extracts of Ginkgo biloba. Quercetin has been well established to possess neuroprotective, cardioprotective, and chemopreventive properties.

The major longevity effect of quercetin was determined using *C. elegans*. In 2007, Kampkotter *et al.* reported, for the first time, the longevity effect of quercetin.¹³⁹ They showed that 100 μM quercetin extended the median lifespan of N2 wild-type *C. elegans* by 19%. Subsequently, several reports followed, showing that 100–200 μM quercetin extended the lifespan of *C. elegans*.^{140–142} Moreover, quercetin 3-*O*- β -D-glucopyranoside—a quercetin derivate from onions—was reported to have stronger activity on the extension of the lifespan of worms.¹⁴³ Metabolites of quercetin—quercetin-3'-*O*-methylether or quercetin-4'-*O*-methylether—were also investigated using *C. elegans* for potential longevity effects.¹⁴⁴ In addition, quercetin-3-*O*-glucoside was absorbed by worms to a greater degree than quercetin.¹⁴² Furthermore, 100 mg kg⁻¹ quercetin administration decreased the number of tumor cells but did not affect the survival of Swiss albino mice bearing Ehrlich ascites tumor cells.¹⁴⁵ Using an intricate meta-analysis technique, quercetin was reported to have a lifespan-extending effect through the following pathways: TGF- β signaling, insulin-like signaling, and the p38 MAPK pathways.¹⁴⁶ In addition, quercetin was reported to extend the lifespan independent of daf16, sir2.1, and caloric restriction, but dependent on daf2, sek1, and unc43.^{140,141}

13.3.3 Catechin

Catechin is a flavanol-type flavonoid (flavan-3-ol) possessing antioxidant, cardioprotective, anti-atherogenic, and anti-carcinogenic effects. Catechin and its derivatives, such as epicatechins (EC), epicatechins-3-gallate (ECG), epigallocatechin (EGC), epigallocatechin-3-gallate (EGCG), and gallicetin