cuticles of leaves from various woody species (Krauss *et al.*, 1997) or in cell walls of conifer needles (Schnitzler *et al.*, 1996; Fischbach *et al.*, 1999) provide screening against UV-B radiation; however, a general screening function for bound hydroxycinnamic acids is questionable because extraction of soluble phenolics from isolated epidermal peels often results in highly UV-transmitting samples (Lautenschlager-Fleury, 1955; Caldwell, 1971; Robberecht and Caldwell, 1978; Markstädter *et al.*, 2001).

The importance of soluble hydroxycinnamic acids for UV-B screening in leaves varies significantly between species and it has been suggested that they are of only minor significance for *Secale cereale* (Burchard *et al.*, 2000), *Vicia faba* (Markstädter *et al.*, 2001), *Ligustrum vulgare* (Tattini *et al.*, 2004) and *Hordeum vulgare* (Kolb and Pfündel, 2005); however, increased epidermal UV-B screening of greenhouse-grown grapevine leaves (*Vitis vinifera*), during acclimation to natural radiation, arises mainly from synthesis of soluble hydroxycinnamic acids (Kolb *et al.*, 2001; Kolb and Pfündel, 2005).

In fruits, data on optical properties of hydroxycinnamic acids are sparse. The presence of hydroxycinnamic acids has been demonstrated in the vacuoles of *V. vinifera* berries (Moskowitz and Hrazdina, 1981) but they contribute little to UV screening in the white *V. vinifera* cultivar 'Bacchus' (Kolb *et al.*, 2003). Significant amounts of the hydroxycinnamic acid derivative verbascoside have been demonstrated in the skin of olive fruits (Servili *et al.*, 1999) which might play a role in UV-B screening. It is uncertain if simple hydroxycinnamic acids contribute to the optical properties of flower surfaces but they can affect petal colouration by forming complexes with flavonoids (Harborne and Williams, 2000).

Colourless flavonoids. The so-called colourless flavonoids, flavones and flavonols (Harborne, 1988), exhibit an absorbance peak located in the UV-A spectral region (about 350 nm), with another peak near 260 nm, that is, outside the natural UV range (Cerovic *et al.*, 2002). Colourless flavonoids, accumulated in the leaf epidermis could, therefore, screen the mesophyll against the damaging effects of UV-A radiation on photosystem II (Turcsányi and Vass, 2000; Nayak *et al.*, 2003; Pfündel, 2003). Flavonoids can also be covalently linked to hydroxycinnamic acids as in the needles of *Pinus sylvestris* (Schnitzler *et al.*, 1996) and in the leaves of *Pisum sativum* (Weissenböck *et al.*, 1986): these molecules combine the absorption properties of both hydroxycinnamic acids and colourless flavonoids.

The absorbance trough in the UV-B spectrum of simple colourless flavonoid derivatives does not necessarily signify inefficient UV-B screening because variations in absorption by these flavonoids correlated with variations in epidermal absorption determined fluorometrically in both the UV-A and in the UV-B spectral range (Burchard *et al.*, 2000; Mazza *et al.*, 2000; Bilger *et al.*, 2001; Markstädter *et al.*, 2001; Kolb and Pfündel, 2005).

Soluble glycosylated flavonoids have been demonstrated in the vacuoles of leaves from many plant species (Tissut and Ravanel, 1980; Hrazdina *et al.*, 1982; Weissenböck *et al.*, 1984, 1986; Hutzler *et al.*, 1998; Kolb *et al.*, 2001) but