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In vitro and in vivo effectiveness of phenolic compounds for the control of postharvest gray mold of table grapes

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ABSTRACT

As the natural antimicrobial metabolites, phenolic compounds were reported to be effective in the inhibition of phytopathogenic fungi, including the postharvest decay agents. However, comprehensive study on the biological activity of phenolic compounds and their application on controlling postharvest gray mold of table grapes is lacking. In this study, the antifungal effect of 18 natural or synthetic phenolic compounds purchased from commercial suppliers, including simple phenolic, phenolic acids, stilbenes and flavonoids, were determined on four gray mold strains by an in vitro agar dilution assay. Overall, seven phenolic compounds were effective on inhibiting *B. cinerea* growth and were selected to test their activity on conidial germination as well as in vivo application on grape berries. Pterostilbene showed the highest antifungal activity and greatly reduced the growth of the mycelia, caused hyphae deformation, suppressed conidial germination of *B. cinerea*, and completely inhibited the germination of conidia at the concentration of 50 mg L^{-1}. Furthermore, treatment of grape berries with pterostilbene and piceatannol significantly reduced the disease incidence and severity. Our results demonstrate the antifungal activity of phenolic compounds and highlight their potentials as an alternative strategy in the control of postharvest gray mold of table grapes.

1. Introduction

The fungus *Botrytis cinerea* causes gray mold, leads to huge postharvest losses and is considered as the main postharvest decay of table grapes (*Vitis vinifera*) (Romanazzi et al., 2012; Youssef and Roberto, 2014). In many countries, synthetic fungicides are not allowed to use for the control of postharvest decay of table grapes, and only sulfur dioxide (SO_2) is permitted to use as an adjuvant. Alternatives to SO_2 are urgently required in view of the hazardous effect to human health caused by SO_2 residues and the bleaching injuries in berries caused by the application of SO_2 (Gándara-Ledezma et al., 2015; Parafati et al., 2015; Romanazzi et al., 2016a).

Among numerous unconventional control strategies, the induction of fruit resistance via application of plant or microorganism products with antimicrobial activity and the physical means can be considered, either alone or as a part of an integrated pest management policy (Romanazzi et al., 2016b). Within plant natural products, phenolic compounds, which widely distribute in the tissues of resistant grapevine cultivars as important secondary metabolites, are thought to be involved in defence response against fungi by forming a chemical barrier that limits pathogen growth and increase plant resistance (Mlikota Gabler et al., 2003; Del Rio et al., 2004; Pizzolitto et al., 2015).

The fungus *B. cinerea* is present in vineyards as part of the environmental microflora, infection of grape often occurs at bloom time, followed by a period of latency, and generally causes disease symptoms when berries begin to ripen and meanwhile phenolic compounds contents changes (Holz et al., 2003; Keller et al., 2003; Liang et al., 2011). Therefore, the phenolic compounds (phytoanticipins) that are constitutively present in grape berries and with potential in inhibiting *B. cinerea* growth are of great interest. Accumulation of certain phenolics are induced as a response to biotic and abiotic stress, and these metabolites are referred to as phytoalexins (Ahuja et al., 2012). Some phytoalexins have broad spectrum of anti-pathogen activities and their accumulation in plants can promote host defense response, e.g. the accumulation of *trans*-resveratrol and catechin in grapes exposed to chitosan and UV-C (Romanazzi et al., 2006), and the accumulation of

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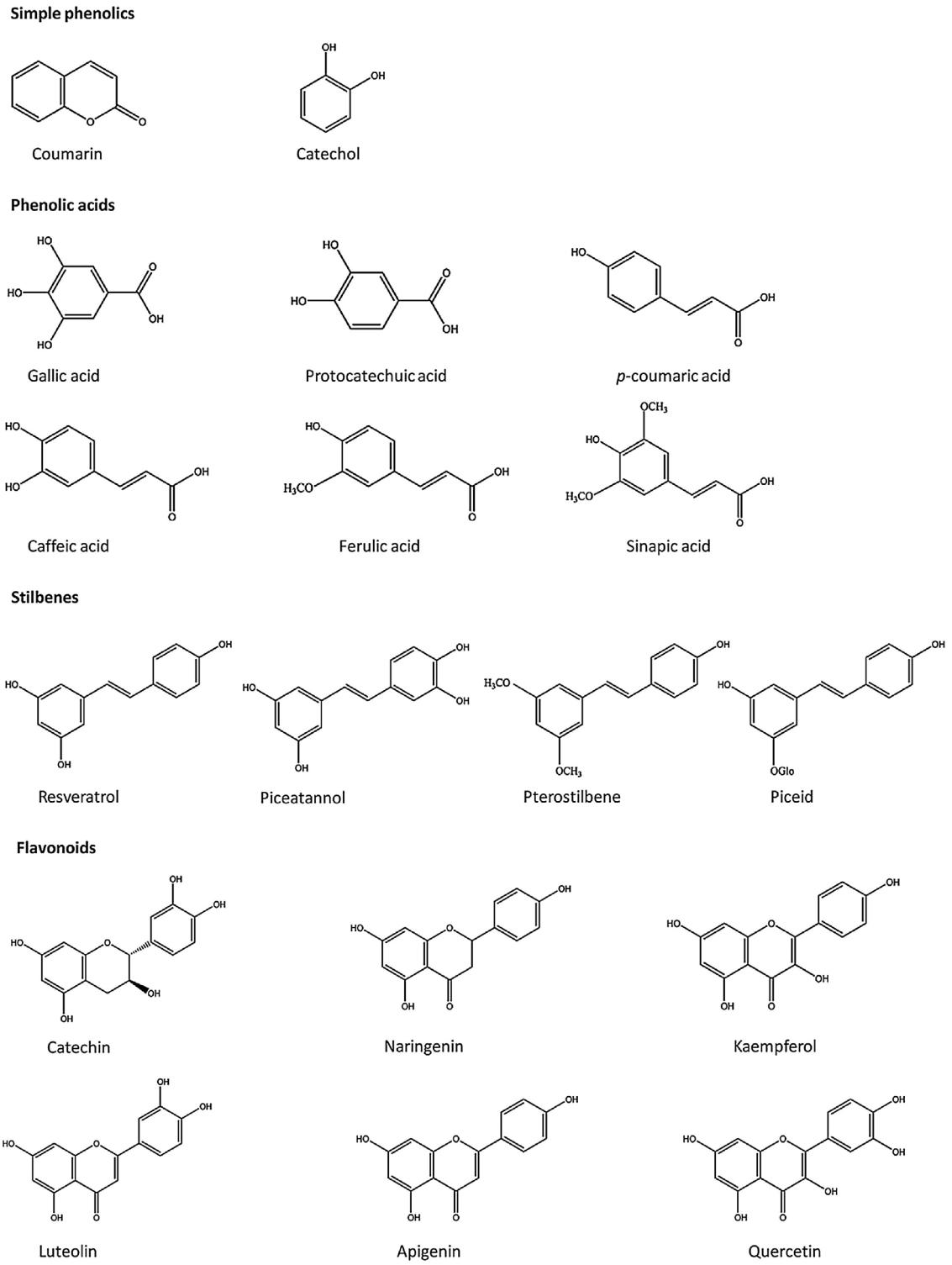

Fig. 1. Structures of the 18 tested phenolic compounds.

stilbenic phytoalexins (resveratrol and viniferin) in grapevine treated with rhizospheric bacteria (Aziz et al., 2016), associated with the development of resistance against *B.cinerea*. At present, several phenolic compounds were proved to have antifungal properties against *Fusarium graminearum* (Gauthier et al., 2016), *Alternaria alternata* (Wang et al., 2017), *Penicillium expansum* (Sanzani et al., 2014), *Plasmopara viticola* (Gabaston et al., 2017) and *B. cinerea* (Mendoza et al., 2013), making them as good "natural pesticide" candidates for improving plant resistance to phytopathogen. However, little is known about the biological activity of phenolic compounds against *B. cinerea*, as well as practical feasibility of their application for protection of table grapes form postharvest gray mold.

In this study, 18 phenolic compounds including simple phenolic, phenolic acids, stilbenes, flavonoids that were previously reported to have antimicrobial activity, were selected and evaluated in the aspect of their antifungal activity against *B. cinerea*, both in vitro and in vivo.