Antifungal activity of the volatile organic compounds produced by *Bacillus velezensis* strains against postharvest fungal pathogens

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Abstract

It is known that Volatile Organic Compounds (VOCs), among several other mechanisms, are responsible for the antagonistic activity produced by microorganisms. In this work the volatilome of three biocontrol *Bacillus velezensis* strains (BUZ-14, I3 and I5) was tested *in vitro* and on fruit against *Botrytis cinerea*, *Monilinia fructicola*, *M. laxa*, *Penicillium italicum*, *P. digitatum* and *P. expansum*. *In vitro,* pathogens growth was significantly inhibited, in particular *M. laxa, M. fructicola* and *P. italicum* (66, 72 and 80 %, respectively) by BUZ-14 and *B. cinerea* (100 %) by I3 and I5, compared to the control. *In vivo* tests also showed significant inhibitions since volatile metabolites of I3 reduced grey mould in grapes by 50 % and those of BUZ-14 decreased brown rot severity in apricots, especially by *M. fructicola,* from 60 to 4 mm. VOCs were identified by solid phase microextraction (SPME) coupled with Gas Chromatography-Mass Spectrometry (GC–MS) and the antifungal activity of some of them was tested both *in vitro* and *in vivo* against the fungal pathogens. The main volatiles identified ranged from 12 to 15 compounds including 2-nonanone, 2-undecanone, 2-heptanone, 1-butanol, acetoin, benzaldehyde, butyl formate, diacetyl, nonane, or pyrazine, among others. Benzaldehyde and diacetyl obtained the lowest minimum inhibitory concentrations *in vitro*, ranging from 0.005 to 0.125 mL L^{-1} depending on the pathogen tested. Moreover, diacetyl was able to control grey mould caused by *B. cinerea* in table grapes with only 0.02 mL L^{-1} and to reduce blue rot in mandarins at the same dose up to 60 %. In this study, diacetyl and benzaldehyde have been identified as promising compounds to apply in active packaging during the postharvest commercialization of fruit. However, prior to the application, it is crucial to determine not only the active dose but also the phytotoxic, since some fruit species such as apples and apricots have proven to be highly sensitive.