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Phytochemicals and Photosynthesis of Grape Berry Exocarp and Seed (Vitis vinifera, cv. Alvarinho): Effects of Foliar Kaolin and Irrigation

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Abstract : Climate changes predictions point to increases in abiotic stress for crop plants in Portugal, like pronounced temperature variation and decreased precipitation, which will have negative impact on grapevine physiology and consequently, on grape berry and wine quality. Short-term mitigation strategies have, therefore, been implemented to alleviate the impacts caused by adverse climatic periods. These strategies include foliar application of kaolin, an inert mineral, which has radiation reflection proprieties that decreases stress from excessive heat/radiation absorbed by its leaves, as well as smart irrigation strategies to avoid water stress. However, little is known about the influence of these mitigation measures on grape berries, neither on the photosynthetic activity nor on the photosynthesis-related metabolic profiles of its various tissues. Moreover, the role of fruit photosynthesis on berry quality is poorly understood. The main objective of our work was to assess the effects of kaolin and irrigation treatments on the photosynthetic activity of grape berry tissues (exocarp and seeds) and on their global metabolic profile, also investigating their possible relationship. We therefore collected berries of field-grown plants of the white grape variety Alvarinho from two distinct microclimates, i.e. from clusters exposed to high light (HL, 150 µmol photons m^{-2} s^{-1}) and low light (LL, 50 µmol photons m^{-2} s^{-1}), from both kaolin and non-kaolin (control) treated plants at three fruit developmental stages (green, véraison and mature). Plant irrigation was applied after harvesting the green berries, which also enabled comparison of véraison and mature berries from irrigated and non-irrigated growth conditions. Photosynthesis was assessed by pulse amplitude modulated chlorophyll fluorescence imaging analysis, and the metabolite profile of both tissues was assessed by complementary metabolomics approaches. Foliar kaolin application resulted in, for instance, an increased photosynthetic activity of the exocarp of LL-grown berries at green developmental stage, as compared to the control non-kaolin treatment, with a concomitant increase in the levels of several lipid-soluble isoprenoids (chlorophylls, carotenoids, and tocopherols). The exocarp of mature berries grown at HL microclimate on kaolin-sprayed non-irrigated plants had higher total sugar levels content than all other treatments, suggesting that foliar application of this mineral results in an increased accumulation of photoassimilates in mature berries. Unbiased liquid chromatography-mass spectrometry-based profiling of semi-polar compounds followed by ASCA (ANOVA simultaneous component analysis) and ANOVA statistical analysis indicated that kaolin had no or inconsistent effect on the flavonoid and phenylpropanoid composition in both seed and exocarp at any developmental stage; in contrast, both microclimate and irrigation influenced the level of several of these compounds depending on berry ripening stage. Overall, our study provides more insight into the effects of mitigation strategies on berry tissue photosynthesis and phytochemistry, under contrasting conditions of cluster light microclimate. We hope that this may contribute to develop sustainable management in vineyards and to maintain grape berries and wines with high quality even at increasing abiotic stress challenges.

Keywords : climate change, grape berry tissues, metabolomics, mitigation strategies
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