

Año: 2025

Título artículo: Grape berries biochemical shifts from vines under summer stress treated with kaolin and silicon mixtures

Revista: Frontiers in Plant Science, 16, 1681593. doi: <https://doi.org/10.3389/fpls.2025.1681593>

Autores: Sandra Pereira, Miguel Baltazar, Zélia Branco, Ana Monteiro, A. Sergio Serrano, Adela Mena Morales, Rebeca Cruz, Susana Casal, Damián Balfagón, Renata Moura, José Moutinho-Pereira, Lia-Tânia Dinis.

RESUMEN:

Introduction: Climate change is intensifying abiotic stress in viticulture, with higher temperatures, water deficits, and increased solar radiation directly affecting grape berry development, biochemical balance, and overall fruit quality. These challenges compromise the delicate balance of sugars, acids, phenolic compounds, and aromatic profiles that define the sensory attributes and typicity of the resulting wine. Innovative practices are therefore needed to sustain fruit quality and composition under increasingly variable and extreme climatic conditions. Silicon (Si) and kaolin (Kl) have already shown highly positive effects in mitigating the impacts of climate change on grapevines.

Methods: Building on this, the aim of this study was to test their combined foliar application to simultaneously alleviate drought and heat stress and enhance berry quality. An integrated assessment was conducted over two growing seasons in a commercial vineyard (*Vitis vinifera* L. cv. Touriga Franca) located at Quinta de Ventozelo (Douro Demarcated Region, Portugal) to evaluate the effects of combined Kl (2%) and Si foliar sprays at different concentrations (2–8%). The study included analyses of fruit biochemical composition, must quality, cuticular wax profile, histological traits, carbon isotope discrimination ($\delta^{13}\text{C}$), hormonal balance, and yield parameters.

Results and discussion: Results showed that Si and Kl treatments modulated secondary metabolite accumulation (phenols, flavonoids, anthocyanins, and tannins) in a season- and stage-dependent manner, with significant increases under milder environmental conditions, particularly in seasons with lower heat and drought stress. This suggests that these products can act as elicitors or stress mitigators, depending on the environmental context. Treated vines maintained higher organic acid levels and lower probable alcohol content, indicating an improved sugar–acid balance. Moreover, the treatments influenced the cuticular wax composition, enhancing triterpenoid content and increasing cuticle thickness and epidermal cell size, which, together with enriched $\delta^{13}\text{C}$ values, support improved water-use efficiency. The hormonal profiles confirmed the role of Si and Kl in fine-tuning stress and growth signals, contributing to better fruit robustness.

Conclusions: These findings demonstrate that the combined foliar application of kaolin and silicon is a promising tool to protect grape berry quality by modulating biochemical composition, cuticular wax profile, histological traits, isotopic signature, and hormonal balance, helping maintain fruit integrity and quality, and compositional stability under the ongoing challenges of climate change.

Agradecimientos:

Los autores agradecen el apoyo y la colaboración del ingeniero Tiago Maia, de Quinta de Ventozelo,

cuya contribución ha sido esencial para el desarrollo de este trabajo. Los autores también agradecen a João Lourenço, de TecniFerti, el suministro de los productos utilizados en este estudio. Los autores también agradecen a la FCT (Fundación Portuguesa para la Ciencia y la Tecnología), en el marco de los proyectos UID/04033/2025 y LA/P/0126/2020 (<https://doi.org/10.54499/LA/P/0126/2020>), y a través del proyecto UID/50006 -Laboratório Associado para a Química Verde -Tecnologias e Processos Limpos, y el proyecto -Tecnologias e Processos Limpos, y el proyecto STrengthS4WineChain -Sinergias Científicas y Tecnológicas para el Desarrollo Sostenible de la Cadena del Vino en la Región Norte, operación n.º NORTE2030-FEDER-01786100, financiado por el Fondo Europeo de Desarrollo Regional (FEDER) a través del Programa Regional Norte 2021-2027 (NORTE2030). Rebeca Cruz agradece el apoyo de la FCT a través del Programa CEEC Individual 2022 (2022.00965. CEECIND) de la FCT. AS y CEEC Individual 2022 (2022.00965. CEECIND). A. Sergio Serrano y Adela Mena Morales agradecen al Fondo Europeo de Desarrollo Regional en el marco del Programa Operativo 2021-2027 de Castilla-La Mancha a través del proyecto «Desarrollo de estrategias para la evaluación de la resiliencia de los cultivos leñosos y las variedades frente al cambio climático».