

The role of berry skin traits in fungus-resistant *PIWI* grapevines

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WiVitis project

The WiVitis project aims to enhance cross-border collaboration between research institutions and viticultural practice within the Upper Rhine region to promote sustainable viticulture and improve adaptation to climate change. The project focuses on the evaluation of *PIWI* grapevine varieties with multiple resistance genes against downy and powdery mildew, with the objective of assessing their resilience under extreme climatic conditions and their susceptibility to fungal pathogens, including *Botrytis cinerea*. *PIWI* varieties are being examined across various sites and environmental conditions. Participating institutions include the Julius Kühn-Institut (Germany), Dienstleistungszentrum Ländlicher Raum Rheinpfalz (Germany), the Research Institute of Organic Agriculture (FiBL-Switzerland), INRAE (France), the State Viticulture Institute Freiburg (WBI) (Germany), and the Swiss Nanoscience Institute (Switzerland).

The importance of the grape skin

The grape berry skin is a complex, multifunctional tissue essential for plant defense and wine quality. It serves as the fruit's main protective barrier, defending against pathogens like *Botrytis cinerea*, reducing mechanical damage, and containing compounds vital to grape flavor and chemistry. Its defense network—comprising the cuticle, waxes, and diverse bioactive chemicals—works synergistically to prevent infection and enhance tolerance to environmental stress.

PIWI varieties differ in skin firmness

At FiBL, we are investigating skin traits in fungus-resistant *PIWI*. We are focusing on a core set consisting of four *PIWI* varieties (Calardis Blanc, Floreal, Souvignier Gris, and Sauvignac) and two European varieties (Chardonnay and Pinot Noir). Using penetrometer measurements (Figure 1A) we found notable variation between varieties on the skin resistance to penetration (Figure 1B). With the varieties Souvignier Gris and Pinot Noir standing out with a significantly more resistant skin.

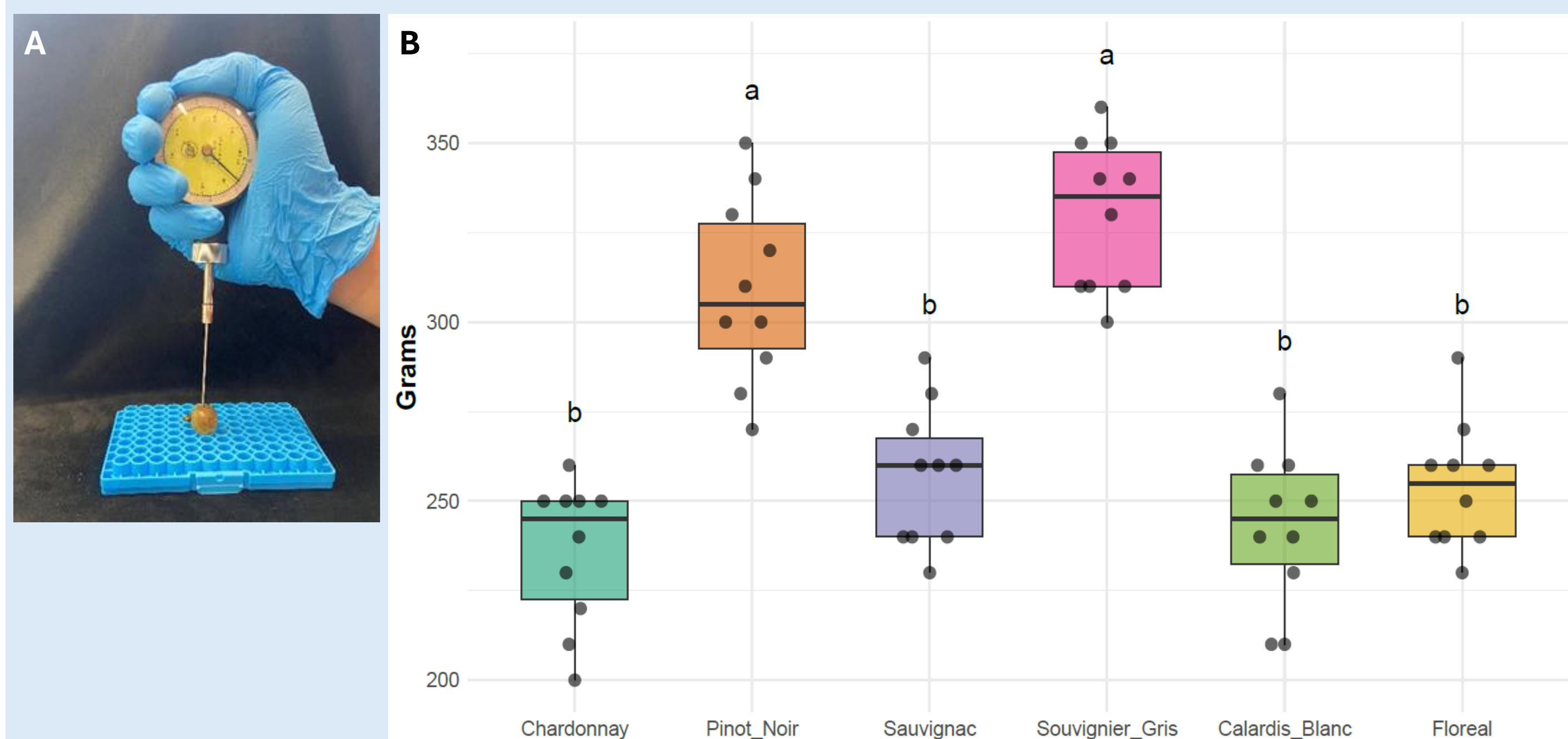


Figure 1: Penetrometer measurements. A) Penetrometer assessment on a grapevine berry. B) Penetrometer results showing the grams needed to push the needle through the berry skin. All the assessments were done on berries at 70° Oechsle. The dots show each individual measurement, and the line indicates the median. The letters indicate significant difference by Anova + Tukey test $p < 0.05$.

The *Botrytis* resistant variety Souvignier Gris has thicker skin

Analysis of the berry skin structure by Cryo-Scanning Electron Microscopy (Cryo-SEM) revealed that the *PIWI* variety Souvignier Gris has a more substantial cuticle layer and larger epidermal cells compared to the European variety Chardonnay (Figure 2).

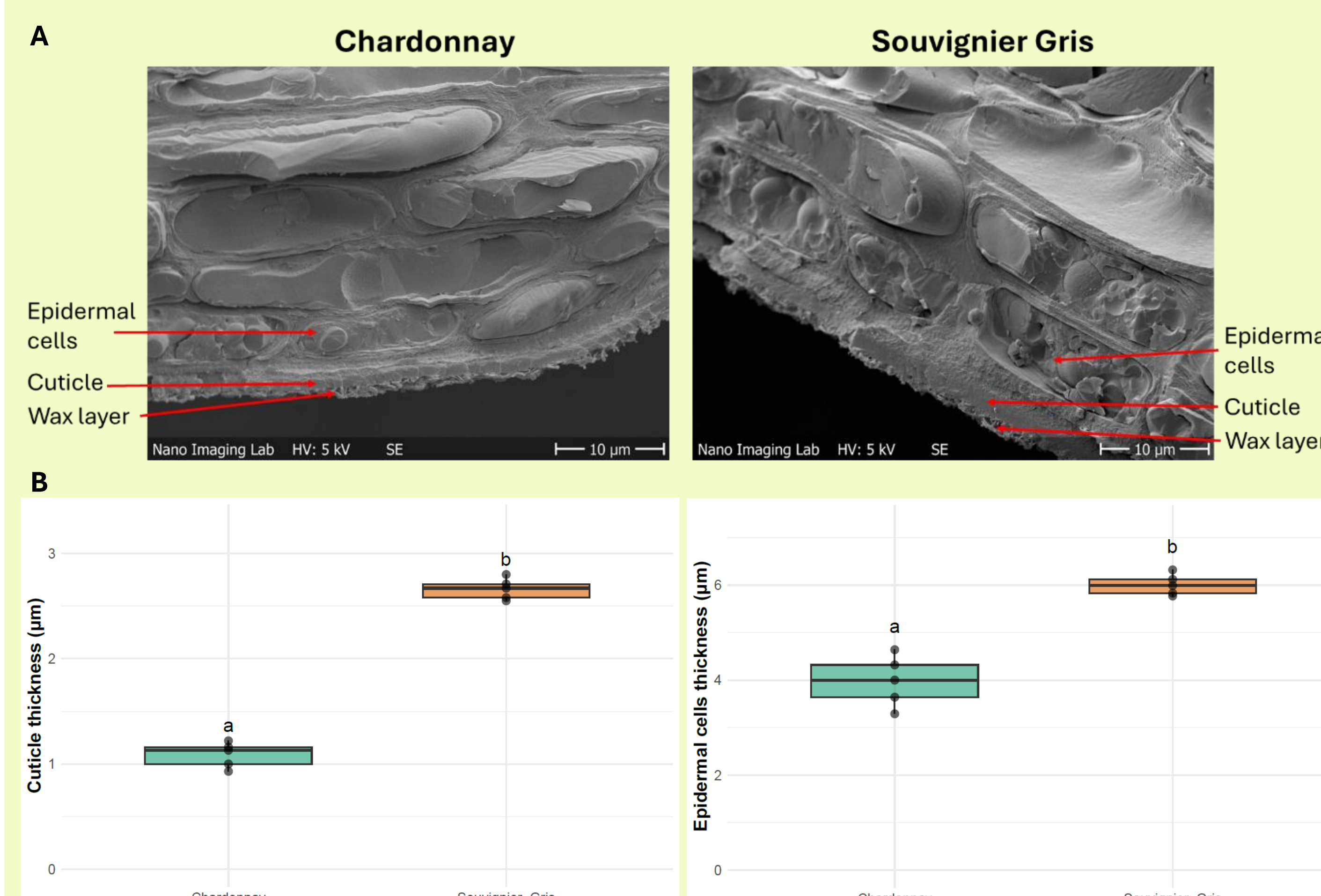


Figure 2: Analysis of berry skin cross sections. A) Cryo-SEM images showing the different layers of the berry skin. Images taken at the Swiss Nanoscience Institute. B) Cuticle and epidermal cells measurements. The letters indicate significant difference by t-test $p < 0.05$.

PIWI varieties show different susceptibility to *Botrytis cinerea*

Preliminary results of *in vitro* tests with single berries artificially inoculated with *Botrytis cinerea* spores suggest differences in their susceptibility to the pathogen infection. Souvignier Gris showed complete resistance to the fungal infection, while Pinot Noir showed the highest susceptibility (Figure 3).

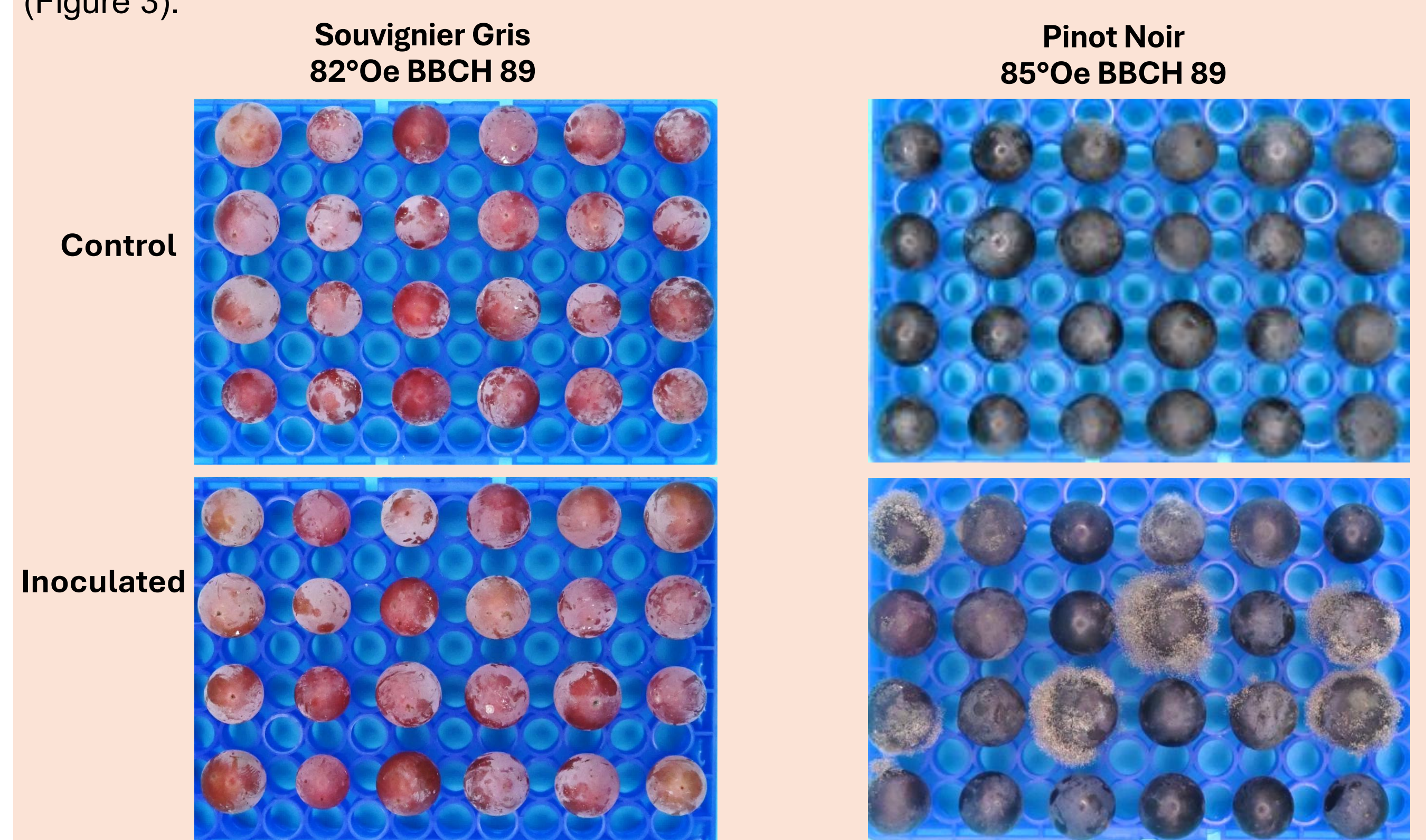


Figure 3: *In vitro* tests with single berries artificially inoculated with *Botrytis cinerea* (50,000 conidia/ml) and incubated at 21°C under high humidity (95%) for 14 days under a 16 h light, 8 h darkness cycle.

Epicuticular wax morphology differs among varieties

CRYO-SEM of the berry skin allowed to detect differences in the morphology of the epicuticular waxes among varieties and across different developmental stages. The *Botrytis* resistant variety Souvignier Gris showed a distinct wax morphology, with membranous platelets and thread-like extensions (Figure 4A). Similar morphologies were also observed in the susceptible varieties Pinot Noir and Calardis blanc but only at later developmental stage (Figure 4B).

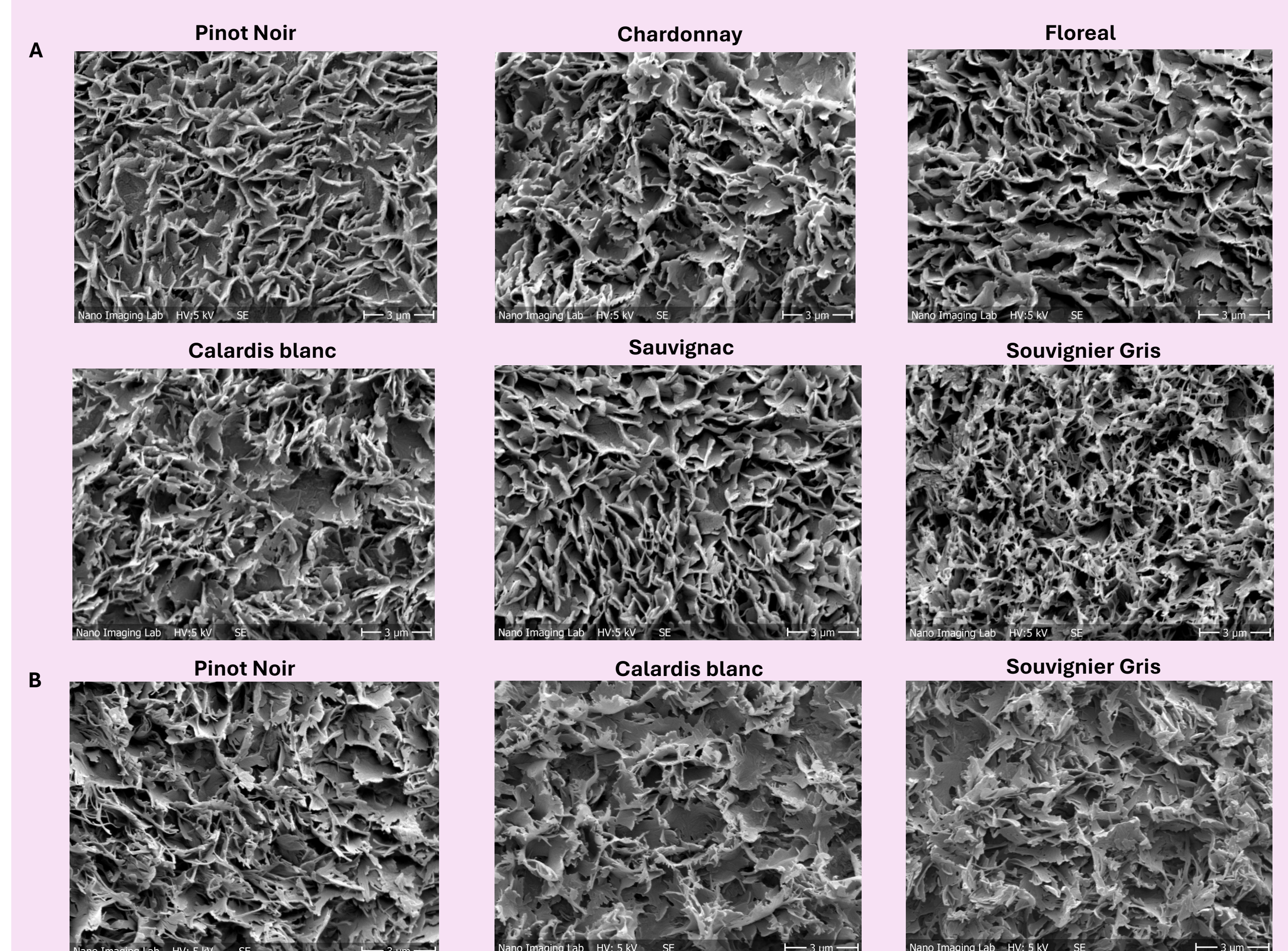


Figure 4: Analysis of berry skin surface by Cryo-SEM. A) Berries of the 4 *PIWI* varieties and the 2 European varieties collected in early August at BBCH 80 and Oechsle less than 30. B) Berries collected in late September at BBCH 89 and Oechsle over 70.

Conclusions

Our preliminary data indicate that *PIWI* grapevine varieties exhibit differences in skin thickness, penetration resistance, and epicuticular wax composition, which may contribute to their varying levels of resistance to *Botrytis cinerea*. The variety Souvignier Gris, which displays the highest resistance to *B. cinerea* infection, is characterized by distinct skin thickness, stability and epicuticular wax morphology—traits that may underlie its enhanced defense against the pathogen. Although these findings are promising, further research is required to validate and expand upon these results.