Foods 2025 Conference
The 6th International Electronic Conference on Foods
Future Horizons in Foods and Sustainability
28–30 October 2025 | Online

Innovative lab-on-chip for the rapid detection of polyphenolic compounds in olives and their derivatives

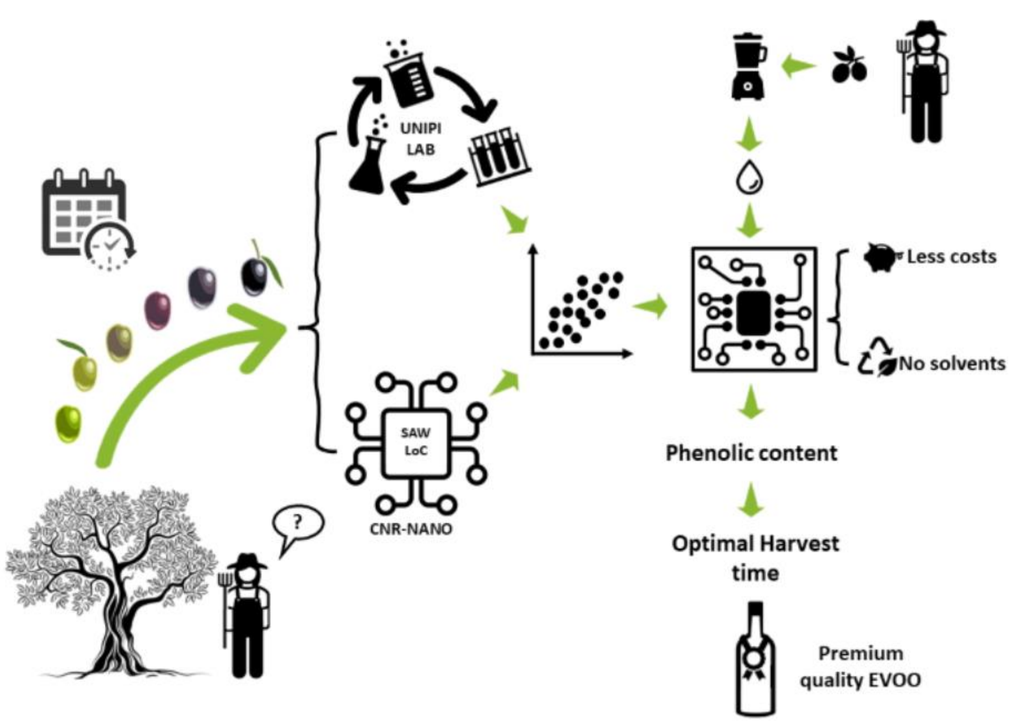
Alessandro Bianchi [1], Giorgia Tori [2], Neetu Malik [2], Isabella Taglieri [1], Mariacristina Gagliardi [2], Marco Cecchini [2], Antonella Battisti [2], Francesca Venturi [1], Chiara Sanmartin [1]

1 Department of Agriculture, Food and Environment, University of Pisa, Via del Borghetto 80, I-56124 Pisa, Italy
2 NEST, Nanoscience Institute – CNR and Scuola Normale Superiore, p.zza S. Silvestro 12, 56127 Pisa, Italy

Introduction

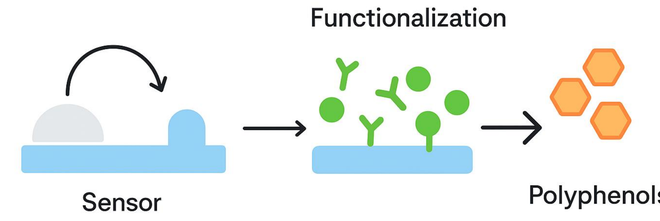
Extra virgin olive oil (EVOO) is a key component of the Mediterranean diet, worldwide appreciated for its nutritional and health-promoting properties. The quality of EVOO strongly depends on the ripening stage of the olives, which affects the phenolic content, oxidative stability, and sensory profile. Currently, phenolic analysis requires time-consuming and expensive laboratory procedures. Therefore, there is a growing need for rapid, reliable, and sustainable tools to assess olive ripeness directly in the field.

The objective of this study was to develop a portable Lab-On-Chip platform integrating Quartz Crystal Microbalance with Dissipation monitoring (QCM-D) for the rapid assessment of olive phenolic content at various ripening stages, minimizing the need for expensive and time-consuming laboratory procedures.



Materials and Methods

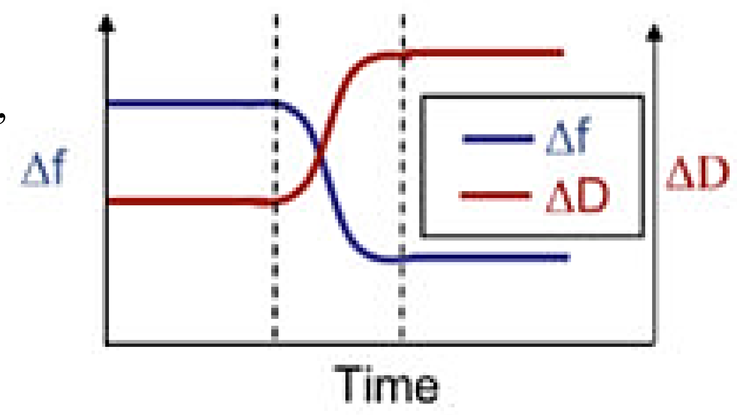
Sixty olive samples were collected at different ripening stages (from green to fully ripe) across three cultivars, along with thirty corresponding oil samples. Phenolic content was quantified using both the QCM-D device and the conventional Folin–Ciocalteu (FC) method, allowing for direct comparison. Sensor surfaces were functionalized with bio-derived polymers, enabling selective binding of polyphenols. Standard solutions of hydroxytyrosol and tyrosol were used for calibration. The QCM-D responses (frequency shift Δf and dissipation ΔD) were recorded, and the analysis time was below 10 minutes per sample.



Operative Steps: **i) Sample preparation:** Phenolic standards prepared; olives from different cultivars and ripening stages collected and divided for chemical analysis and QCM-D testing.

ii)Chemical and sensory characterization: Carpological data, phenolic content, antioxidant capacity, legal quality parameters, and sensory panel evaluation performed on fruit and EVOO extracts.

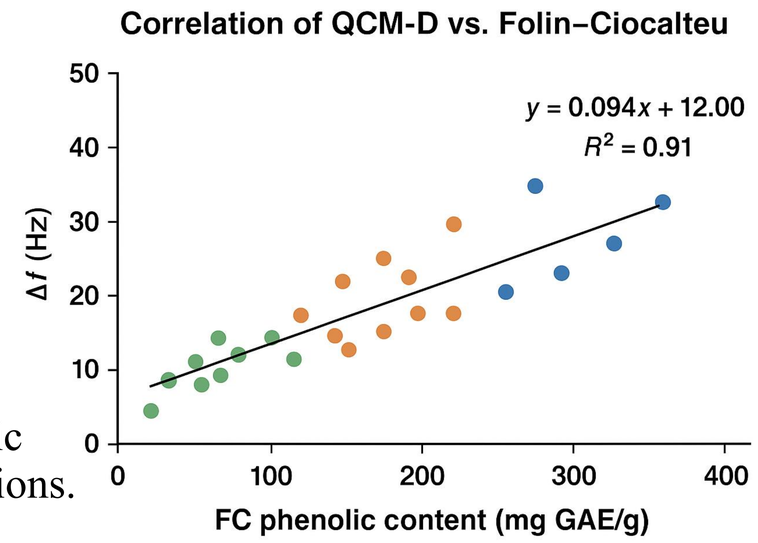
iii) QCM-D functionalization and testing: Quartz crystals functionalized with binding agents (BSA, gelatin, peptides) and tested with standard solutions and real extracts to assess sensitivity, selectivity, and reproducibility.



iv) Data analysis and calibration: Calibration curves established between QCM-D response and phenolic concentration; chemometric models applied for validation and correlation with ripening index.

Preliminary Results

The QCM-D method showed a strong correlation with the FC assay, across a wide range of total polyphenol contents (250–1300 mg GAE/kg). Repeatability tests confirmed excellent precision.



The system successfully differentiated samples according to ripening stage: early-harvest olives exhibited the highest polyphenolic load and QCM-D signals, while more mature fruits showed decreasing values.

Compared to the FC method, the QCM-D analysis required only a mild and non-toxic hydroalcoholic solvent (20% ethanol), which makes the protocol faster, safer, and more suitable for on-site applications.

Conclusions

The Lab-On-Chip QCM-D platform provides a rapid, reliable, and environmentally friendly alternative to the FC method for phenolic analysis in olives and oils. It enables improved decision-making regarding harvest timing and quality control, while requiring less time, lower costs, and safer reagents.

A multivariate predictive model (PLS regression) is currently being developed to correlate QCM-D fingerprints with detailed phenolic profiles and sensory attributes of the resulting oils.

Lab-on-chip for sustainable Olive ValuE chain
Finanziato dall'Unione europe NextGenerationEU
Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA
Università di Pisa
CNRNANO

This work was supported by the European Union - NextGenerationEU, within the PRIN 2022, project "LOVE".