

SUSTAINABLE BIOPESTICIDES FROM CITRUS WASTES INNOVATIVE EXTRACTION METHODS FOR ECO-FRIENDLY CROP PROTECTION

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INTRODUCTION

The push for sustainable agriculture drives the search for eco-friendly pest control solutions. The European Union supports Integrated Pest Management highlighting biopesticides as safer, sustainable alternatives. Orange peels, a by-product of *Citrus* processing, contain valuable bioactive compounds with antimicrobial and pesticidal properties but are often discarded (1). This study aims to recover these compounds from *Citrus* waste to create sustainable biopesticides, reducing the environmental impact of common pesticides. By extracting active molecules from the peel (both albedo and flavedo) (Fig.1) using the innovative Naviglio Extractor (2) the research explores eco-friendly alternatives to synthetic pesticides.

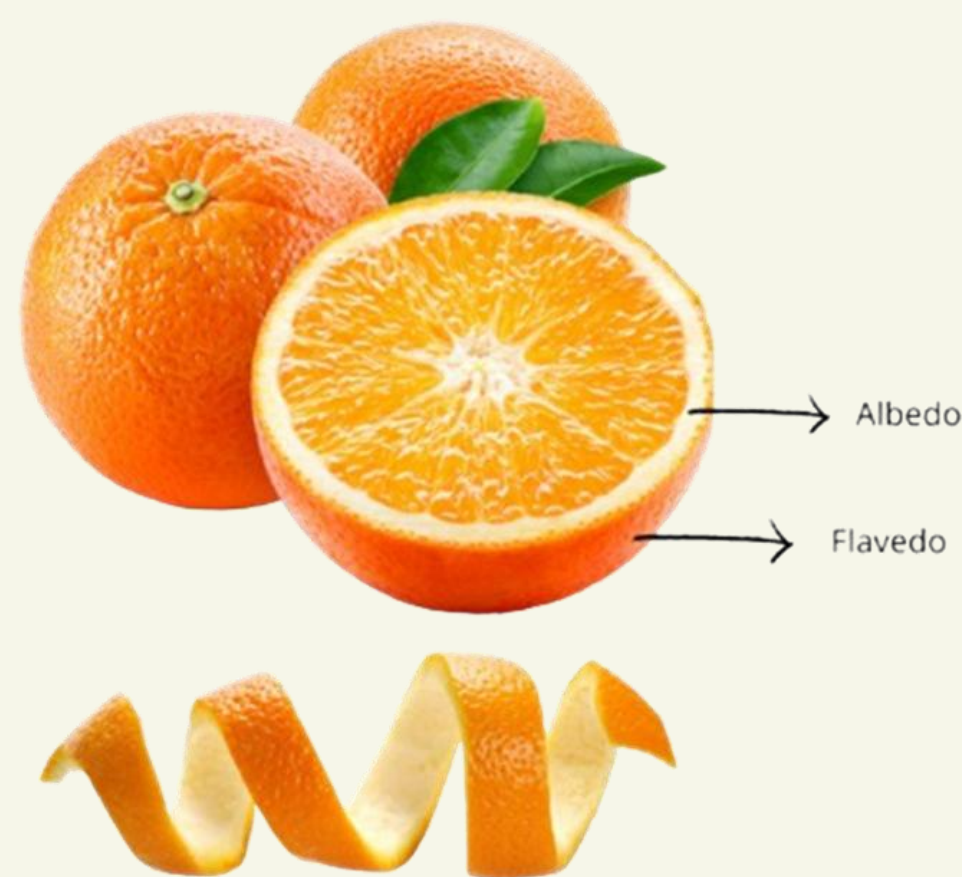


Fig. 1 - Orange structure

METHODS

Extraction Technique

- Innovative Naviglio Extractor: A solid-liquid extraction technique operating at room temperature using negative pressure to enhance active molecules recovery from Flavedo and Flavedo + Albedo samples (Fig.2). Extraction times tested: 2 h, 22 h, 96 h.

Analytical Methods

- Total Phenolic Content (TPC) and Radical-Scavenging Activity (RSA): Antioxidant potential assessment (3).
- UV-Vis Spectroscopy: Identification of carotenoid presence.
- LC-MS Analysis: Chemical profile characterization of extracts.

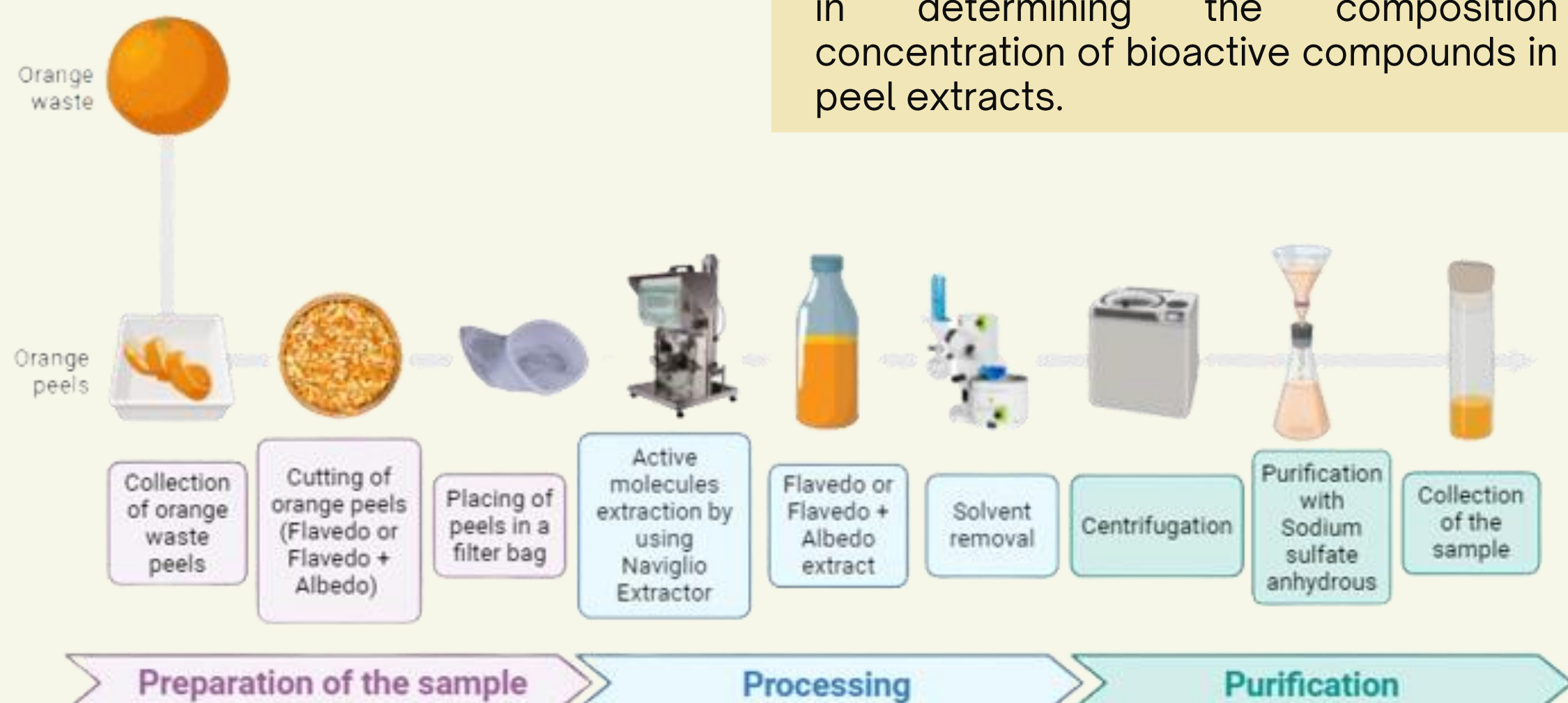


Fig. 2 - Flavedo and Flavedo + Albedo samples processing

RESULTS

The Naviglio extractor produced extracts with high antioxidant activity, showing comparable total phenolic content (TPC) between Flavedo + Albedo and Flavedo samples, regardless the extraction time (Fig. 3). However, Flavedo samples exhibited greater antioxidant activity than Flavedo + Albedo samples (Fig. 4). UV-Vis analysis confirmed the presence of carotenoids in Naviglio extracts through higher absorbance and distinctive peaks (Fig. 5). LC-MS analysis identified several bioactive compounds (Fig. 6), with their intensity decreasing as extraction time increased, highlighting the crucial role of extraction duration in determining the composition and concentration of bioactive compounds in orange peel extracts.

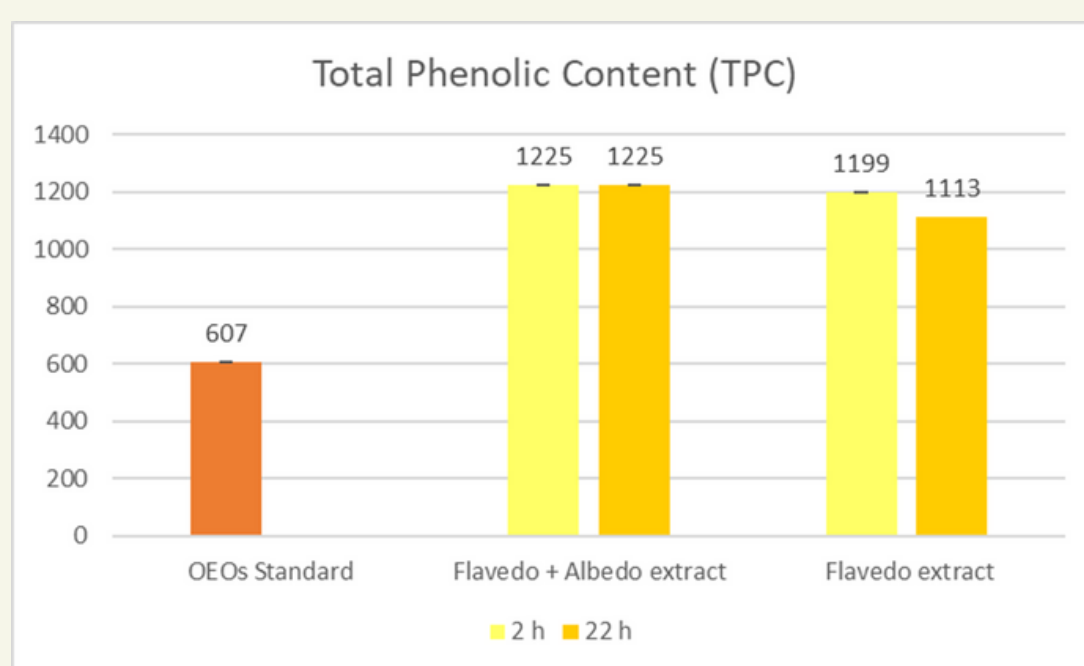


Fig.3- TPC OEOs, Flavedo + Albedo and Flavedo samples at different times

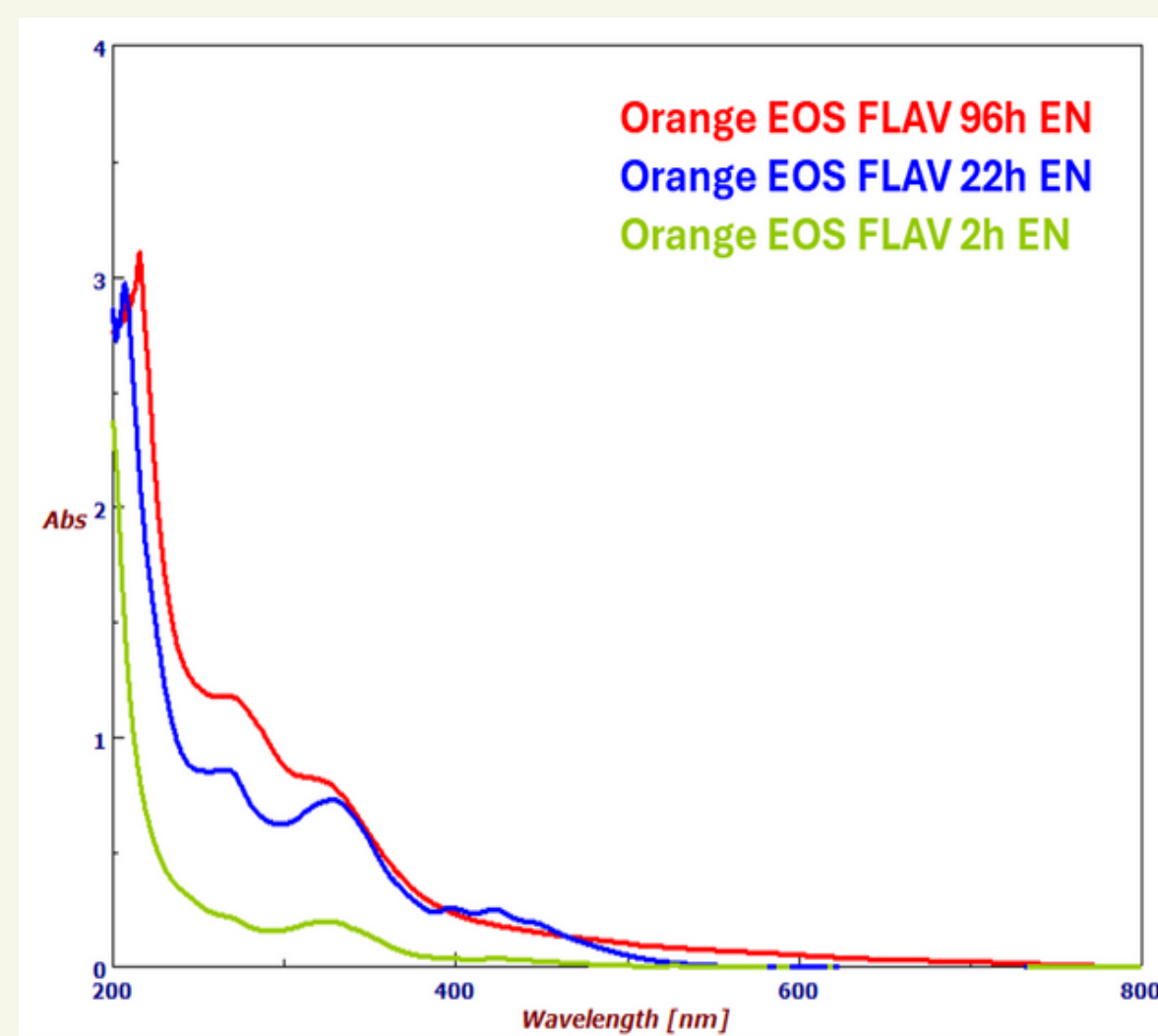


Fig. 5- UV-vis spectra of Flavedo extracts at different times

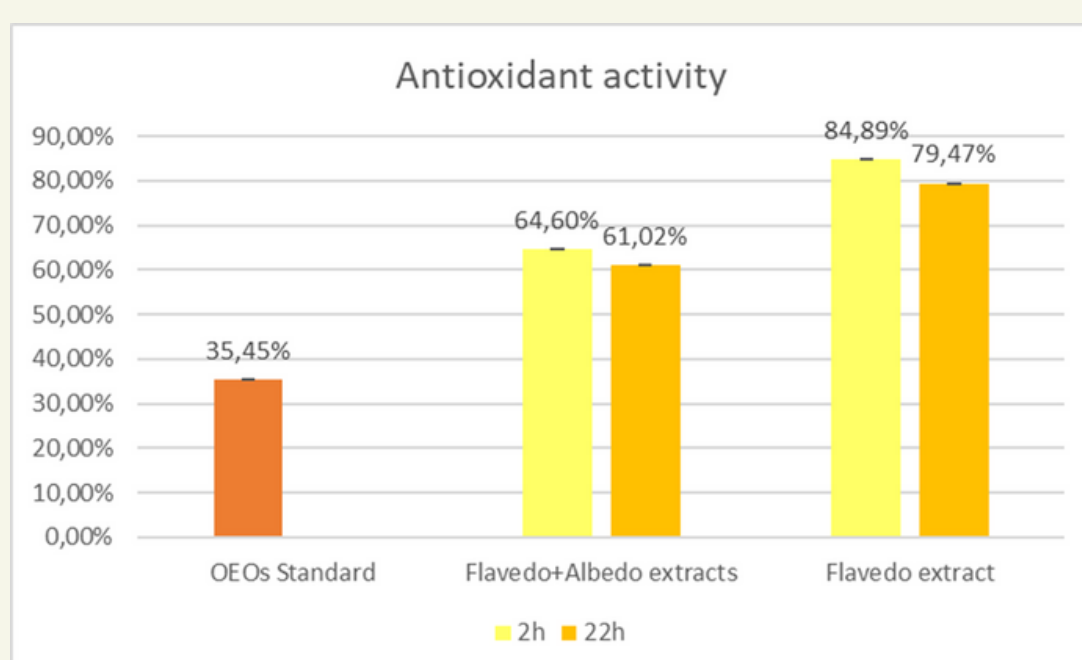


Fig. 4 - DPPH assay of OEOs, Flavedo + Albedo and Flavedo samples at different times

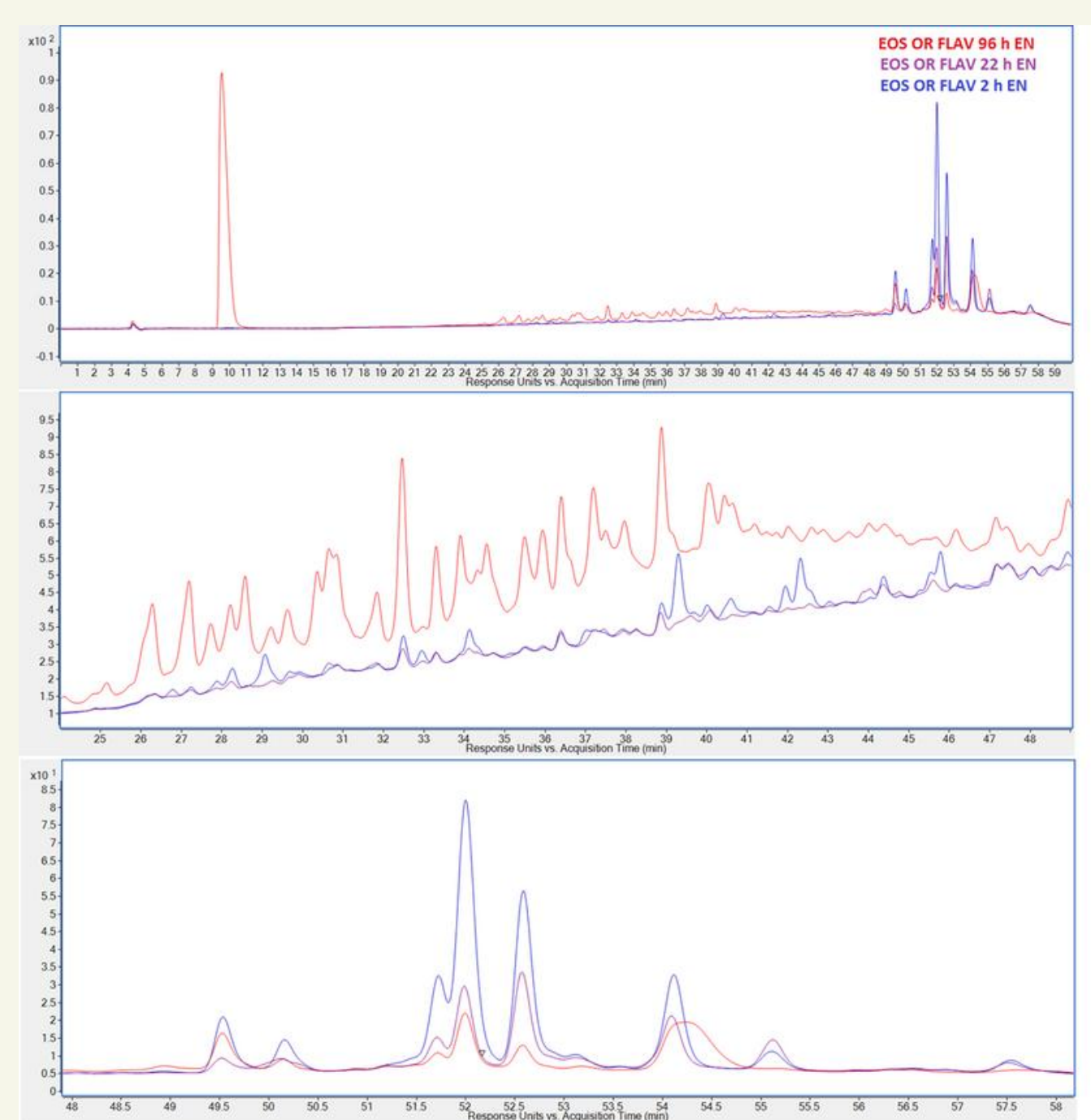


Fig. 6- LC-MS of the Flavedo extracts at different time

CONCLUSIONS

This study highlights the potential of orange peels, a *Citrus* waste by-product, as a source of active molecules for developing sustainable biopesticides. Using the eco-friendly Naviglio extractor, the research efficiently recovers these compounds, endowed with antioxidant activity and promising chemical profiles. The findings support a circular economy by converting waste into valuable resources, offering an eco-friendly alternative to chemical pesticides and contributing to sustainable crop protection.

References

1. Cirrincione F. et al. (2024) *Food Research International* 187, 114422
2. Naviglio D et al. (2003) *Analytical Letters* 36(8), 1647-1659
3. Famiglietti M. et al. (2022) *Foods* 11(14), 2078