



An integrated toolbox for improved verification and prevention of adulterations and non-compliances in organic and geographical indications food supply chain

Grant Agreement Number: 101083579

D.3.1: Operational system of THEROS components for monitoring, verification, adulteration detection, and traceability

Document Identification			
Status	Final	Due Date	Monday, 31 March 2025
Version	1.0	Submission Date	31/03/2025
Related WP	WP3	Document Reference	D.3.1
Related Deliverable(s)	D2.2, D.4.1	Dissemination Level	PU/SEN
Lead Participant	AUTH	Document Type:	Other
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This project has received funding under grant agreement No 101083579. It is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Research Executive Agency (REA). Neither the European Union nor the granting authority can be held responsible for them.

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Document History			
Version	Date	Modified by	Modification reason
0.1	20/12/2024	Achilleas Zalidis	Document creation, table of contents formatting
0.2	20/01/2025	Nejc Vesel	Chapter 2 editing
0.3	12/02/2025	Marilena Paraskeva	Chapter 5 editing
0.4	17/02/2025	Achilleas Zalidis, Dimitra Xenitopoulou	Editing of the sections of Chapter 3
0.5	21/02/2025	Michal Kepka	Chapter 4 editing
0.6	28/02/2025	Alfonso Sillero Sanchez, Jara Quintana	Chapter 6 editing

Document History			
Version	Date	Modified by	Modification reason
0.7	07/03/2025	Achilleas Zalidis, Dimitra Xenitopoulou	Executive summary, conclusions, and finalisation of the draft for revision
0.8	10/03/2025	Marilena Paraskeva	Quality Assurance review
0.9	21/03/2025	Joaquin Garrido, Panagiotis Madesis, Dimitra Tsiakou	Peer review
1.0	28/03/2025	Achilleas Zalidis	Final version to be submitted

Quality Control		
Role	Who (Partner short name)	Approval Date
Deliverable leader	Achilleas Zalidis, AUTH	28/03/2025
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Executive Summary

Food fraud and non-compliance in GI and organic products are some of the most significant challenges to food safety and authenticity. Traditional verification solutions, which are often founded on on-site inspection and manual analysis, are time-consuming, costly, and prone to inefficiencies. The THEROS project addresses these drawbacks by the integration of state-of-the-art technologies to deliver real-time, data-driven, and automated monitoring solutions. The reader will gain an insight into the system's architecture, function, and operational integration, along with how it aids in improving food supply chain transparency and compliance.

This deliverable, part of the Horizon Europe project THEROS, provides the operational system of the THEROS components aimed at monitoring, verification, adulteration, and traceability within the organic and geographical indication (GI) food supply chain. Conducted under Work Package 3 (WP3), this work aims at describing the technological innovations made towards improving transparency, compliance, and mitigation of food fraud. The report describes the system architecture, major functions, and integration processes of the THEROS toolbox components based on the end-user specifications given in the document “THEROS **D2.2**: Report on THEROS toolbox specifications and system architecture”. The purpose is to capture and consolidate the information so as to enhance the verification of information across the food supply chain.

This deliverable serves as a reference for policymakers, control and certification bodies, and industry stakeholders, guiding the adoption of innovative monitoring and verification solutions within the organic and GI food sectors.

The WP3-generated operational system consolidates five major components: an **EO-based ecosystem services** component, utilizing satellite imagery and machine learning approaches for large-scale observation of organic agriculture activities, the differentiation of organic and conventional farming, and detecting inconsistencies; **MEMS-based photonics systems and models**, consisting of portable spectroscopic sensors for non-destructive, real-time food product monitoring, facilitating prompt adulteration detection and quality control; an **IoT sensor network**, placing intelligent sensors in all stages of the food chain for monitoring quality parameter values throughout storage and transportation, ensuring product integrity and regulation enforcement; a **DNA-based authenticity kit**, a molecular device for species and region of origin confirmation to enhance traceability and ensure protection from mislabeling and fraudulent replacement; and a **blockchain enhanced traceability system**, an secure, decentralized ledger tracking all supply chain transactions with full data integrity, providing a brief history for checking and conformity.

The results of this deliverable will be further refined and integrated into the THEROS **D4.1**: Mobile applications for data collection and transparent data governance (initial version) and **D4.2**: Mobile applications for data collection and transparent data

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governance (final version), where user-centric tools and models will enhance the practical application of these technologies in real-world settings. Also, the data collected in the context of the current deliverable will be better shaped and joined into the THEROS **D4.3: Data Harmonisation Platform and verification engine**. Moreover, in WP5, these components will undergo extensive testing in THEROS pilot demonstrations in **Serbia, Greece, and Spain**, aiming to assess the system's performance under real-world conditions.