Publishable Summary for 23IND13 ScreenFood
Metrology for food safety in the circular economy: targeted and screening methods for contaminants in food and recycled packaging

Overview

To ensure a high level of food safety throughout production and distribution, it is crucial to improve and harmonise analytical techniques for contaminant quantification. This constitutes the basis for reliable data regarding food product compliance with regulations and for resolving disputes and minimising financial losses within the food industry. The project will develop reference methods and reference materials for quantifying contaminants in both food and food packaging, with a specific emphasis on recycled materials. These metrological tools will aid industries in guaranteeing the delivery of safe food and sustainable packaging while adhering to regulatory requirements.

Need

Ensuring food safety is of paramount importance, as it involves safeguarding consumers from potential harm caused by food contamination. The focus on safety is a central priority for EU lawmakers. Furthermore, as outlined in the circular economy action plan, the development of a sustainable food system is a critical objective. Industries have a pivotal role to play in achieving this objective by adopting strategies that reduce food waste, minimise environmental impact, and prioritise consumer well-being.

However, progress towards these goals can sometimes face obstacles, including the risk of eroding consumer confidence in food quality. Such challenges can negatively impact the standing of the European food industry in the global market. Factors such as the increased use of recycled and sustainable packaging materials and the growing awareness of emerging contaminants necessitate immediate attention.

End-users of measurements related to contaminants, including analytical laboratories, regulatory authorities, and decision-makers, rely on accurate analytical procedures with traceability to SI units. Consistency and accuracy in assessing and managing contaminants are vital to making informed decisions and maintaining the integrity of the food supply chain. However, meeting these requirements can be challenging. Existing standard procedures may require enhancements, or they may not exist for specific analytes or matrices (or their combinations).

Furthermore, appropriate (Certified) Reference Materials covering contaminants in relevant food and food contact materials are often not available.

Improving and harmonising reliable analytical procedures that provide traceability to SI units are essential actions to address these gaps effectively. Such measurement capabilities must be supported by reference materials that address specific matrix requirements, relevant analytes, and emerging trends in food packaging.

Experience has shown that, especially in the case of complex analytical procedures, training laboratory staff in sample preparation, instrumental analyses, and result interpretation is urgently needed alongside harmonised protocols and reference materials to ensure quality control effectively.

Objectives

The overall aim of the project is to develop analytical strategies and reference materials supporting food and food packaging industries in the provision of safe and sustainable products compliant to legislation. The project will establish a metrological network able to provide, in collaboration with research centres and industries, innovative harmonised standards, internationally recognised, aimed at the detection and quantification of contaminants in food, with a focus on those possibly migrated from virgin and recycled food packaging materials.

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METROLOGY PARTNERSHIP EURAMET

The specific objectives are:

1. To improve protocols for the **quantification of the mineral oil aromatic hydrocarbons (MOAH) fraction** and for the quantification of the fraction consisting of substances with three or more aromatic ring systems (3+MOAH), including sample preparation procedures for food matrices not covered in the development of ISO/DIS 20122. This will include selected food types from the SCoPAFF categories with a fat content between 4 % and 50 % (MOAH ≤ 1.0 mg/kg) and below 4 % (MOAH ≤ 0.5 mg/kg). Reliable MOAH quantification shall be demonstrated in presence of biogenic interfering substances.
2. To develop sensitive analytical procedures for detecting and quantifying **per- and polyfluoroalkyl substances (PFAS) in selected matrices,** in line with the requirements of Commission Regulation (EU) 2023/915, meeting the limits of quantification (LOQ) specified in Commission Recommendation (EU) 2022/1431, ranging from ≤ 0.002 µg/kg to ≤ 0.5 µg/kg for relevant PFAS groups depending on the matrix. The following PFAS will be addressed: PFOS, PFOA, PFNA e PFHxS, as well as emerging perfluoroalkyl substances (e.g., GenX. ADONA, PAPs, Fluorotelomer alcohols and sulfonates). Food matrices will be selected in order to cover categories that pose different analytical challenges, from (i) water/moisture-content (ii) Fatty and (iii) High protein matrices. Food packaging materials (both virgin and recycled) will be studied as well.
3. To develop **traceable and highly accurate reference materials** for quality control and quality assurance purposes. These materials will be designed for key contaminants like MOSH, MOAH, and PFAS in relevant food and food-related matrices, such as vegetable oil, infant formula, fish, milk, and food packaging.
4. Develop screening methods addressing new/existing organic and inorganic contaminants, in virgin and recycled packaging such as bio-based food contact materials and reusable materials. To detect contaminants' migration in food simulants and selected food matrices as well as to foster the research in the discovery of Emerging and Novel PFAS through non-targeted screening. To implement metrological approaches for the determination of total extractable organic fluorine (EOF) in selected matrices as well as to address direct transportable/portable rapid screening methods for performance and comparison to existing laboratory methods.
5. To **facilitate the take up of the technology and measurement infrastructure** by the supply chain (e.g., regulatory bodies, NMIs, DIs and EMN for Safe and Sustainable Food), standards developing organisations (e.g., CEN, ISO, UNI, IOC, Codex Alimentarius), and end users (e.g., reference laboratories, the food industry), to ensure that the advancements made in the project benefit the wider community.

Progress beyond the state of the art and results

Objective 1: Identification and Quantification of MOSH and MOAH in Food Matrices:
The project will enhance the applicability of the procedure outlined in ISO/DIS 20122. This will involve a thorough revision of the Standard Operating Procedure (SOP) with detailed instructions to eliminate analytical interferences and assess chromatograms. The goal is to harmonise the procedure and enable routine application with quantification limits for MOAH in all food matrices at least as specified by SCoPAFF: 2.0 mg/kg for fats and oils and fatty foods with fat contents above 50 %, 1.0 mg/kg for foods with a fat content between 4 % and 50 % and 0.5 mg/kg for foods with a fat content below 4 %. This will cover food matrices so far not included in validation studies. For the first time, 3+MOAH will explicitly be addressed. Additionally, a video training resource will be developed to facilitate the harmonised integration and interpretation of chromatographic data. GCxGC procedures will be developed and harmonised to identify the patterns of the 3+MOAH fraction. This is expected to significantly improve the identification of toxicological relevant MOAH contamination sources.
Objective 2: Sensitive Analytical Procedures for PFAS Detection and Quantification:
The project will develop reference methods and materials to support industries and regulatory bodies in detecting PFAS in relevant food matrices and food packaging materials. Focus areas include drinking water, milk, fish, and vegetables, which pose analytical challenges. The outcomes are expected to contribute to the evolving regulatory framework concerning PFAS, both within and outside the EU. Various extraction and clean-up methods will be explored to streamline sample preparation while maintaining sensitivity and reproducibility. The project will provide validated analytical methods for relevant matrices, such as drinking water, fish, milk, vegetables, and packaging materials, with limits of quantification ranging from ≤ 0.002 µg/kg to ≤ 0.500 µg/kg, in line with recent regulations.

Objective 3: Development of Traceable and Accurate Reference Materials:
Reference materials and candidate Certified Reference Materials (CRMs) will be developed for the determination of MOSH/MOAH in food matrices and PFAS in selected food and food packaging matrices. This will support trueness, precision and between-laboratory consistency of measurement results in routine laboratories. For mineral oils, matrix-free reference materials will be created, addressing a current market gap, and will be provided for spiking selected food matrices. The project will also work on efficient and automated clean-up processes to minimise the use of hazardous substances. Novel isotopically labelled compounds will be investigated to enhance the sensitivity and specificity of HPLC-MS-based analytical methods for PFAS quantification in selected matrices.
Objective 4: Development and Validation of Screening Methods for Contaminants in Packaging:
The project will develop validated and, wherever possible, SI-traceable methods to support standardised quantification of organic and inorganic contaminants, including non-polar organics (e.g. hydrocarbons, oligomers), PFAS, total extractable organic fluorine, and metals. New methods will be validated and implemented to reduce measurement uncertainty or support relevant legislation. Screening methods will be devised to address the complexities of monitoring contaminants in recycled and virgin packaging materials, including eco-friendly containers. These methods will be standardised and employed in migration studies. For recycled packaging, they will enable the identification and quantification of chemical contaminants from previous uses, such as ink residues, adhesives, or cleaning agents. In the case of novel/biobased materials, these methods will help detect potential natural chemical compounds that may migrate into food, affecting its quality and safety.

Outcomes and impact

Outcomes for Industrial and Other User Communities:

The food industry will gain access to validated measurement methods and reference materials essential for accurately quantifying chemical agents that may unintentionally contaminate food products due to inadvertent or adventitious contamination. Unlike contaminants deliberately added for profit through food adulteration or fraud, accidental contamination typically occurs at extremely low levels, posing a significant challenge for detection. Therefore, determining trace levels of contaminants near the limits of detection necessitates state-of-the-art analytical techniques. The project's outcomes will bolster the food industry's capacity to detect and quantify accidental chemical contaminants in both food and packaging materials, thereby mitigating the risk of product recalls.

Presently, the lack of reference materials for certain contaminant analyses poses a significant challenge, as laboratories must provide quality assurance for compliance or accreditation purposes. Food industry laboratories will be able to employ (Certified) Reference Materials (CRMs) as quality control materials for key contaminants. This will expedite the rapid implementation and maintenance of reliable measurement results.

Specifically addressing Mineral Oil Saturated Hydrocarbons (MOSH) and Mineral Oil Aromatic Hydrocarbons (MOAH), the project will develop a comprehensive video training for the proper application of the complex LC-GC-FID analytical procedure. Additionally, improved methodologies for characterising the MOAH fraction regarding the compounds displaying 3 and more rings (3+MOAH) will be developed, enhancing the capabilities to meet the requirements set by EFSA.

Outcomes for the Metrology and Scientific Communities:

The metrology and scientific communities will have the opportunity to participate in international interlaboratory studies, allowing them to benchmark themselves against peers, enhance their abilities to measure certain contaminants more accurately in selected matrices, with lower detection limits.

The project's analytical methods and the results from three interlaboratory comparisons will serve as an unparalleled foundation for metrologically traceable reference materials. Innovative analytical approaches for assessing packaging materials in terms of inorganic and organic contaminants will be disseminated to the metrology and scientific communities through peer-reviewed publications, measurement protocols, and guides. Additionally, reliable data on 3+MOAH, as requested by the European Food Safety Authority (EFSA), will be made available in the near future.

These outcomes will impact on measurement and testing laboratories and academics, enabling them to produce more accurate and reproducible scientific results and assess their applicability to diverse investigative areas. As a result of these interlaboratory comparisons, all uncertainty parameters for method validation and

guidance on using uncertainty measurements in conformity checks or legislative compliance will be obtained. These considerations and results will be disseminated through scientific papers and communications at conferences organised for the food chemistry or metrology community.

On a broader scale, the project will fortify collaboration among European National Metrology Institutes (NMIs) in the realm of food safety, enhancing their competence and competitiveness in characterising mineral oils, PFAS, and organic and inorganic contaminants within a competitive international market. The project's outcomes will impact metrology thanks to the strong connections of the consortium with relevant metrology networks, research infrastructures, and confederations, such as the European Metrology Network for Safe and Sustainable Food, METROFOOD RI, and IMEKOFOODS.

Outcomes for Relevant Standards:

The consortium will actively promote the project's results within the standardisation community and contribute inputs to the standardisation process of organisations like ISO, CEN, and UNI. Specifically, standards relevant to the project that are either in preparation or revision will be identified, and efforts to advance these standards will be suggested to the appropriate working groups or committees.

The project's results will serve as a foundation for the development of new international standards and standard operating procedures (SOPs) related to horizontal methods, contaminants, and packaging. This is particularly important for challenging food matrices and infant foods, where special attention is required due to the low body mass during child development.

Furthermore, the project will propose guidelines covering various aspects, such as production, packaging materials, and storage, following the project's conclusions. It will also create a specific protocol for the identification of 3+MOAH.

The validation of existing methods, involving additions or revisions to uncertainty and analytical parameters or application fields, will be a primary focus.

The project's ultimate goal is to submit inputs with innovative significance to existing and new standards promoted by international standardisation bodies, ultimately advancing measurement and testing practices.

Longer-Term Economic, Social, and Environmental Impacts:

Recognising food contamination as a global challenge, the World Health Organization has highlighted its significance in various documents and reports. This project will address the imperative need for monitoring and reducing contaminants in food by developing Certified Reference Materials (CRMs) and validated, harmonised quantitative methods. The resulting safer foods will improve the health status of consumers, reducing social healthcare costs and benefiting citizens worldwide.

Furthermore, the project will offer insights into the sources of contamination for selected contaminants in food. Understanding the factors influencing chemical burden in food will aid in reducing contamination throughout the entire farm-to-fork continuum.

The project's findings on contamination from various types of food packaging will raise awareness and promote the safe use of recycled materials, enhancing the trust of end-users and consumers. Additionally, packaging and environmental associations will derive benefits from the project's outcomes.

In the long term, the project aligns with societal goals by addressing areas for improving the safety of food contact materials and contributing to the circular economy. As a result, the project will enhance knowledge about the potential impact of recyclates used in packaging on the quality and safety of packed food. This is especially relevant as European Union countries are gradually increasing the use of recycled materials in packaging and recycling cycles.

In conclusion, this project's outcomes will have a substantial and positive impact on food safety, measurement accuracy, standardisation, and long-term economic, social, and environmental aspects, aligning with global efforts to ensure the safety and sustainability of the food supply chain. This is aligned with 2030 Agenda for Sustainable Development of United Nation [3], in particular referring to “End hunger, achieve food security and improved nutrition and promote sustainable agriculture” (Objective 2).

List of publications

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Project start date and duration:		01 June 2024, 36 months
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Internal Beneficiaries: 1. INRIM, Italy 2. BAM, Germany 3. GUM, Poland 4. IMBiH, Bosnia and Herzegovina 5. JSI, Slovenia 6. NIVA, Norway 7. TUBITAK, Türkiye 8. ZRS Koper, Slovenia	External Beneficiaries: 9. Chiron, Norway 10. CVUA FR, Germany 11. DTU, Denmark 12. EUROLAB, Europe 13. IAPR, Greece 14. MRI, Germany 15. Natureef, Poland 16. Sciensano, Belgium 17. UT, Estonia	Unfunded Beneficiaries: 18. AS, Germany 19. GEA, Slovenia 20. Gerstel, Germany 21. JOTIS, Greece 22. KB Folie Polska, Poland 23. Nestlé Waters, France
Associated Partners: 24. KLZH, Switzerland, 25. LGC, United Kingdom, 26. METAS, Switzerland, 27. realcycle, Switzerland, 28. SQT, Switzerland.		