



FONDAZIONE  
EDMUND MACH



# DIFFA23

DIRECT INJECTION FOOD FLAVOUR ANALYTICS

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BOOK OF ABSTRACTS

Fondazione Edmund Mach

San Michele all'Adige (TN), Italy

20 - 22 September 2023

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1st International Symposium on  
Direct Injection Food Flavour Analytics (DIFFA)

*Edited by*

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**Proceedings of the DIFFA23 - 1<sup>st</sup> International Symposium on Direct Injection  
Food Flavour Analytics**

**Fondazione Edmund Mach – San Michele All’Adige (TN) Italy**

**20-22 September 2023**

This book collects the conference proceedings of the 1<sup>st</sup> International Symposium on Direct Injection Food Flavour Analytics, held at the Fondazione Edmund Mach from 20<sup>th</sup> to 22<sup>nd</sup> September 2023.





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## FOREWORD

Volatile organic compounds (VOCs), particularly flavour compounds, represent an invaluable noninvasive metric to follow the multi-faceted journey of food, from the farm to the fork and beyond, such as relating to the human microbiome after consumption or in addressing reduction strategies for food waste. VOCs thereby serve as a direct and swift means of measurement and notably act as a main driver of the perceived quality of food.

Mass spectrometry (MS) is an established yet increasingly pivotal tool in food and beverage characterization with a broad range of applications. When coupled with gas chromatography (GC), it stands as the predominant analytical method for exploring many aspects of food, from safety to traceability and nutritional aspects, and equally facilitates control measures in quality and process monitoring.

Recent remarkable advancements in both technology and methodology have paved the way for highly sensitive, specific, rapid, robust, and validated MS-based techniques that have become indispensable in food science and technology research and application. A subgroup of these technologies has been devised over the past two decades in the form of analytical approaches that enable the analysis of VOCs through direct injection. These methods have gained attention for their rapid, highly sensitive and high-throughput analytical capabilities.

A leading technology in this area is proton transfer reaction-mass spectrometry (PTR-MS), which has driven many innovative applications for direct flavour/food analysis. Commencing 2003, the University of Innsbruck, Austria, has organized a biennial event dedicated specifically to PTR-MS and its applications, including a focused session on food science and technology.

The **1<sup>st</sup> International Symposium on Direct Injection Food Flavour Analytics (DIFFA23)** was conceived with the backdrop of the PTR-MS conference but with a different aim, namely to embrace a broader community beyond PTR-MS uses, encompassing similar direct injection mass spectrometry (DIMS) technologies, such as atmospheric pressure chemical ionization-mass spectrometry (APCI-MS) and selected ion flow tube-mass spectrometry (SIFT-MS), with a primary emphasis on flavor compounds. It was also not exclusive to MS-based analytical techniques, but welcomed the inclusion of complementary non-MS approaches, such as solid-state sensors, fast gas chromatographic direct approaches and ion mobility spectrometry (IMS), amongst others, to ensure a wider reach and broader engagement. The meeting was established to foster scientific discussions of common interest and facilitate scientific collaborations. This book of abstract highlights the details of the event and contains the contribution summaries of both the oral and poster presentations.

The conference featured one plenary and four keynote lectures delivered by distinguished guests, as well as numerous invited and contributed talks and 25 poster presentations, with 97 attendees from different EU states, the USA, the UK, Israel and New Zealand. The event provided valuable insights into direct injection food/flavour analytics, with reviews from pioneering scientists who played key roles in developing and advancing DIMS methods in its early days, such as Andy Taylor, Patrik Španěl and Jean-Luc Le-Quéré, showcasing both historical developments and recent advancements in analytical performance and novel applications. Topics discussed included nose-space analysis of composite foods, rapid and high-throughput phenotyping, fermentation monitoring, both as an

innovative technological tool and for investigating the human microbiota, advanced data analysis and data mining tools. These are just a few examples of the themes explored during the conference.

Numerous partners contributed to the success of the event: the sponsors, whose engaging presentations and financial support sustained the quality of the meeting and ensured that the conference fees were kept to a minimum, as well as various supporting institutions and patronages. Special thanks go to the Fondazione Edmund Mach (FEM) for its scientific contributions and for hosting the conference at the Research and Innovation Centre, as well as the Division of Mass Spectrometry of the Italian Chemistry Society (DSM-SCI) for their organizational support and creation and hosting of the conference website. The invaluable support from these companies and institutions are further acknowledged through inclusion of their logos on the back cover of this book.

The conference started a fruitful exchange of results, ideas and issues amongst scientists working with direct tools to monitor VOCs in food science and technology, with broad attendance from sensory and applications scientists from academia and industry.

We would like to thank all those who, through their participation and support, made this event possible, which exceeded our most ambitious expectations.

Thank you all, and we look forward to seeing you at the next edition.

On behalf of the Scientific Committee

*Franco Biasioli, Jonathan Beauchamp, Pat Silcock*

## CONFERENCE PROGRAM

20<sup>th</sup> September 2023

12.30-14.00 Registration and welcome buffet

### Conference opening

14.00-14.10	Welcome addresses Fulvio Magni - <i>Società Chimica Italiana-Divisione Spettrometria di Massa</i> Mario Pezzotti - <i>Fondazione Edmund Mach</i>
14.10-14.20	Why DIFFA23? Franco Biasioli - <i>Fondazione Edmund Mach</i>
14.20-15.05	Plenary lecture: <i>DI-MS – A game changer for flavour research?</i> Andy Taylor - <i>University of Nottingham</i>

### Session 1 | Unlocking Flavour with DIMS

Chairs: Pat Silcock & Nina Cleve

15.05-15.35	Jonathan Beauchamp - Fraunhofer Institute for Process Engineering and Packaging IVV <i>The long and winding road: a flavoursome tale of PTR-MS</i>
15.35-15.55	Graham Eyres - <i>University of Otago</i> <i>What is Flavour and how can DIMS help untangle the puzzle?</i>
15.55-16.15	Andreas Mauracher - <i>IONICON</i> <i>Advantages of Next-Gen PTR-ToF instruments for food and flavour sciences</i>

16.15-17.00 Tea break and poster session

## Session 2 | DIMS in Health and Wellbeing

Chairs: Donatella Caruso & Eirini Pegiou

17.00-17.20	Josep Rupert - <i>Wageningen University &amp; Research</i> <i>Signalling volatile compounds in the human gut microbiota: new avenues offered by direct analytical methods.</i>
17.20-17.40	Chris Mayhew - <i>University of Innsbruck</i> <i>Real-Time Trace Analysis of Breath Volatiles using Proton Transfer Reaction Mass Spectrometry: implications for in-vivo flavour release measurements</i>
17.40-18.00	Enrico Davoli - <i>Istituto Mario Negri</i> <i>Direct analysis of sex-wellness products using a field deployable MS equipped with a Direct Sampling Atmospheric Pressure (DSAP) source</i>
18.00-18.20	Corrado Di Natale - <i>University of Rome Tor Vergata</i> <i>Direct injection mass spectrometry and gas sensors: a teacher-pupil relationship</i>
18.20-18.40	Luca Cappellin - <i>University of Padua</i> <i>Improved compound identification in direct VOC analysis using an EI&amp;CI-TOFMS</i>
19.00	Welcome cocktail - cloister of the monastery and historical cellar

**21<sup>st</sup> September 2023**

**Session 3 | Linking DIMS Data to Sensory Perception**

Chairs: Graham Eyres & Iuliia Khomenko

9.00-9.30	Jean-Luc Le-Quéré - <i>INRAE-CSGA Dijon</i> <i>Twenty years of Direct Injection Mass Spectrometry for aroma research in Dijon</i>
9.30-9.50	Catrienus De Jong - <i>Wageningen University &amp; Research</i> <i>Exploring new in vivo and in vitro methods to integrate sensory and instrumental analysis to get insight and improve the flavour of plant-based food products during oral processing and drinking</i>
9.50-10.10	Markus Stieger - <i>Wageningen University &amp; Research</i> <i>In vivo aroma release and sensory perception of composite foods</i>
10.10-10.20	Michele Pedrotti - <i>Wageningen University &amp; Research</i> <i>Characterization of plant-based milks by combining sensory analysis with headspace and nose-space direct injection mass spectrometry</i>
10.20-10.30	Karina Gonzalez-Estanol - <i>Wageningen University &amp; Research</i> <i>In vivo analysis of nose-space concentration by direct injection mass spectrometry to study the effect of chewing rate on aroma release during food consumption</i>
10.30-10.40	Laura Hill - <i>University of Nottingham</i> <i>Understanding the relationship between lipids, capsaicin and aroma release in confectionery</i>

10.40-11.10 Coffee break and poster session

## Session 4 | Flavour Complexity and Cooking

Chairs: Fulvio Magni & Caroline Perltier

11.10-11.30	Samo Smrke - <i>ZHAW School of Life Sciences and Facility Management</i> <i>Development of fast-GC PTR-MS method for coffee VOCs analysis</i>
11.30-11.45	Nina Cleve - <i>Fraunhofer Institute for Process Engineering and Packaging IVV</i> <i>Milk matters: Unraveling retronasal aroma release and perception of coffee by combining in vivo nosespace analytics with dynamic sensory methods</i>
11.45-12.05	Tomasz Majchrzak - <i>Gdansk University of Technology</i> <i>What happens when food goes into oil during deep frying? Monitoring the first minutes of frying using PTR-MS</i>
12.05-12.20	Gregory Schmauch - <i>Rational F&amp;E GmbH</i> <i>Influence of product quantity, cooking parameter and flow tube pressure on the measurement with Sift-MS in a cooking oven</i>
12.20-12.40	Vaughan Langford - <i>Syft Technologies</i> <i>Application of SIFT-MS to chemical and sensory screening of packaging materials</i>
12.40-14.00	Conference group photo and lunch

## Session 5 | Latest DIMS Showcasing

Chairs: Jonathan Beauchamp & Karina Estanol-Gonzalez

- |             |  |
|-------------|--|
| 14.00-14.15 | Terry Bates - <i>Cornell University</i><br><i>Rapid headspace solid-phase microextraction with sheets with direct analysis in real time mass spectrometry (SPMESH-DART-MS) of derivatized volatile phenols in grape juices and wines</i> |
| 14.15-14.30 | Matteo Tonezzer - <i>University of Cagliari</i><br><i>PTR-MS as a tool to understand and improve the performance of electronic noses</i>   |
| 14.30-14.45 | Andrea Warburton - <i>University of Otago</i><br><i>Application of PTR-ToF-MS to monitor development of flavour in sourdough</i>   |
| 14.45-15.05 | Paolo Redegalli - <i>Shimadzu Italia S.r.l.</i><br><i>Characterization of isoflavones and its metabolites in foods by direct probe ionization mass spectrometer (DPiMS) with high resolution detection</i>                               |
| 15.05-15.25 | Hansruedi Gygax - <i>GAS Dortmund</i><br><i>GC-IMS instruments and their use in food and flavour analysis</i>  |

15.25-16.15 Tea break and poster session

## Session 6 | Microbial, Fermentation and Modelling

Chairs: Riccardo Flamini & Michele Pedrotti

- |             |  |
|-------------|--|
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| 16.45-17.05 | Vittorio Capozzi - <i>Institute of Sciences of Food Production - National Research Council of Italy (CNR)</i><br><i>DIMS techniques and the study on microbial VOCs in food: flavour attributes, fermentation monitoring and emerging trends</i> |
| 17.05-17.20 | Eirini Pegiou - <i>Wageningen University &amp; Research</i><br><i>Easy and fast detection of abnormal olive brine fermentation – A showcase of SPOTDETECT.</i>   |
| 17.20-17.40 | Caroline Peltier - <i>INRAE</i><br><i>Automatic pretreatment and multiblock analysis of flavor release and sensory temporal data simultaneously collected in vivo</i>  |
| 17.40-18.00 | Ana Rita Monforte - <i>AFB INTERNATIONAL</i><br><i>Modelling the kinetics of flavour formation &amp; release as a function of ingredients addition in real food systems</i>  |
| 18.00-18.20 | Pietro Franceschi - <i>Fondazione Edmund Mach</i><br><i>Mining datasets from untargeted direct analytical methods: a data analyst point of view</i>  |
| 18.20-18.35 | Mickael Le Behec - <i>Institute of Analytical Sciences and Physico-Chemistry for Environment and Materials (IPREM)</i><br><i>Volatile fingerprints of food thanks to the untargeted use of SIFT-MS raw data</i>                                  |

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**22<sup>nd</sup> September 2023**

**Session 7 | Food Spoilage and Off-Flavour**

Chairs: Catreinus de Jong & Brian Farneti

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10.00-10.15	Antonella Grosso - <i>University of Bolzano</i> <i>Monitoring autoxidation of vegetable oils by proton transfer reaction mass spectrometry</i>
10.15-10.30	Pedro Martinez Noguera - <i>University of Copenhagen</i> <i>Using PTR-ToF-MS to quantify microbial off-flavors geosmin and 2-methylisoborneol in water. Method development, performance assessment and comparison with established GC-MS methods</i>
10.30-10.45	Davide Papurello - <i>Turin Polytechnic</i> <i>Supporting sustainable energy production by PTR-MS: a review on the work accomplished on biofuel production from food waste to SOFC systems</i>
10.45-11.05	Rupert Holzinger - <i>Utrecht University</i> <i>Using SI traceable gas standards to improve the accuracy of untargeted PTR-MS measurements</i>

11.05-11.45 Coffee break and Poster Session

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Chairs: Rupert Holzinger & Vittorio Capozzi

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12.40-12.55	Eugenio Aprea - <i>University of Trento</i> <i>Contribution of volatile organic compounds to multifloral honey flavor</i>
12.55-13.15	Daniele Zatta - <i>University of Padua</i> <i>Comparative analysis of VOC purification techniques in complex cooking emission: adsorption, photocatalysis and combined systems.</i>
13.15-13.30	Closing remarks Fulvio Magni - <i>Società Chimica Italiana-Divisione Spettrometria di Massa</i> Franco Biasioli - <i>Fondazione Edmund Mach</i>
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### **O.03 *In vivo* analysis of nose-space concentration by direct injection mass spectrometry to study the effect of chewing rate on aroma release during food consumption**

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*Summary:* In this study, the effect of chewing rate, food structure and composition on aroma release and perception of food was investigated by coupling two real time methods; nose-space analysis via PTR-MS to quantify aroma release and time intensity analysis to measure sensory perception.

*Keywords:* Time-Intensity (TI), Aroma release, Proton Transfer Reaction–Time of Flight–Mass Spectrometry (PTR–ToF–MS), Composite foods, Oral processing behaviour

## **1 Introduction**

Flavour analysis has shown to be an important application area for direct injection mass spectrometry (e.g., Proton Transfer Reaction Mass Spectrometry (PTR-MS) and Selected ion flow tube mass spectrometry SIFT-MS). It has been used not only to understand and manipulate flavour release at different stages of food process conditions, but also for setting quality control parameters and product specifications [1,2]. Furthermore, the release of volatile organic compounds (VOCs) from the food matrix into the oral and nasal cavity during consumption is critical for aroma perception.

The combined actions of mastication and salivation lead to the breakdown of foods and formation of safe-to-swallow bolus [3,4]. During oral processing of many semi-solid and solid foods, the number of bolus fragments increases and their size decreases, leading to an increase of total surface area of food bolus particles, which facilitates the release of taste and aroma compounds from the food matrix enhancing taste and aroma perception [5,6]. Coupling of dynamic sensory methods with simultaneous nose-space analysis by high sensitivity direct injection mass spectrometry has proven to be an optimal approach to gather the most information on the underlying mechanisms of aroma release and sensory perception during food consumption.

The aims of this study were to investigate the effects of (i) chewing rate (fast vs slow), and (ii) carrier addition (bread, sponge cake) on *in vivo* aroma release and perception of strawberry jams varying in composition using nose space analysis via PTR-MS combined with Time-Intensity (TI).

## **2 Experimental**

Three strawberry jams differing in sugar content and viscosity were spiked with citral 0.4% (w/w) and limonene 0.4% (w/w). They were evaluated alone and in combination with two carriers (bread, sponge cake). *In vivo* release of citral and limonene were characterised using Proton-Transfer-Reaction-Time-of-Flight-Mass-Spectrometry (PTR-ToF-MS) and simultaneously the corresponding aroma perception (citrus aroma intensity) was determined using Time-Intensity (TI) (n=8, triplicate).

Standardised fast and slow chewing protocols (chewing at a chewing rate of 1.33 chews/s (fast) or 0.66 chews/s (slow) for 25 s) were applied.

### 3 Results

Carriers' addition to jams increased aroma release while perceived citrus aroma intensity decreased regardless of the chewing rate. A faster chewing rate led to higher aroma release compared to a slower chewing rate for composite foods (carriers with jams) without impacting dynamic perception of citrus aroma intensity. This suggests that the aroma release increase, probably caused by an increase in structural breakdown (total surface area of bolus fragments) of the composite food during mastication, was too limited to cause considerable changes in aroma perception. Jams sugar content had negligible effects on both aroma release of citral and limonene and citrus aroma perception of the composite foods. Increasing the jams viscosity decreased the citrus aroma intensity significantly.

### 4 Conclusions

The simultaneous coupling of PTR-ToF-MS with TI profiling allowed to reveal the presence of cross-modal interactions between food texture and aroma perception in complex, composite food matrices and to quantify the impact of mastication behaviour on *in vivo* aroma release and perception. This study confirms that (a) carrier addition (bread, sponge cake) to strawberry jams strongly influenced both aroma release and perception and (b) chewing rate impacted aroma release without impacting aroma perception of composite foods.

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